ALYTES

INTERNATIONAL JOURNAL OF BATRACHOLOGY

Décembre 1988 **Volume 7, N° 4**

Alytes, 1988, 7 (4) : 125-163.

Notes on *Xenobatrachus* and *Xenorhina* (Amphibia: Microhylidae) from New Guinea with description of nine new species

J.P. BLUM* & J.I. MENZIES**

*Eichhalde 68, 7800 Freiburg, Federal Republic of Germany
**Biology Department, University of Papua New Guinea, Box 320, University P.O., Papua New Guinea

Assembly of a large collection of *Xenobatrachus* and *Xenorhina* species by the authors in east and west New Guinea (Irian Jaya, Indonesia, and Papua New Guinea) made possible some comments on the ecology and systematics of these frogs. A combination of call data and morphometrics revealed that the species known hitherto as *Xenobatrachus rostratus* is a complex of at least six species which may or may not be closely related. Five of these are described as new. Examination of gut content of 40 examples of 13 species suggested that these frogs are specialized earthworm eaters, possibly the ecological equivalent of Gymnophiona which do not occur in New Guinea. We comment on the possible function of the vomero-palatine spikes characteristic of *Xenobatrachus* and describe the peculiar structure of the tongue. Two species (*Xenobatrachus rostratus* and *Xenorhina minima*) are redefined and nine new ones described, distribution is indicated and ecological data provided wherever possible. The relationship of *Xenobatrachus* to *Xenorhina* is discussed and we conclude that it is not yet possible to combine the two genera under the senior name, *Xenorhina*. We suggest that further evidence, not yet to hand, may strengthen reasons for combination. Both genera contain a range of morphotypes from short-legged, small-eyed species known to live underground to longer-legged, larger-eyed species believed to be terrestrial. A key for identification of all species in the two genera is provided.

INTRODUCTION

A recent review of asterophryine microhylid frogs (ZWEIFEL, 1972) recognized eight species of *Xenobatrachus* and six species of *Xenorhina*, but seven of these were known from fewer than a dozen specimens each and four from three or fewer. Little was recorded about their ecology and the calls of the male frogs, so important in distinguishing between morphologically similar species, went unrecorded. Since 1972, one other species, *Xenobatrachus subcroceus* Menzies & Tyler, 1977, has been described together with call data for a number of burrowing frog species of other genera. BURTON (1986) listed all known species in both genera and redefined the tribe Xenorhinini.

There are several possible reasons for our lack of knowledge of *Xenobatrachus* and *Xenorhina*. In the first place, these appear to be largely western genera and herpetological research in the western half of New Guinea has lagged behind studies in Papua New Guinea, where numerous new species of frogs have been described in recent years. Up to 1975, 13 species of these two genera were known to occur west of the Strickland River and only seven to the east (we regard the Strickland River a more natural boundary dividing New Guinea into eastern and western halves than the 141° political border). ZWEIFEL (1972) reported only *Xenorhina doriae* occurring in the south-eastern peninsula of New Guinea, but BURTON (1986) has shown that this is unrelated to other species of *Xenorhina* and transferred it, on anatomical evidence, to *Phrynomantis* (now *Callulops*, see DUBOIS, 1988). In the second place, these two genera consist of fossorial or subfossorial frogs and therefore they are not easy to collect, though the intensity of calls often suggests that they may be common.

This paper derives from studies made in several different areas of New Guinea. BLUM worked in the Eipomek area of the Snow Mountains of Irian Jaya while MENZIES' collections resulted from work in various areas of Papua New Guinea and a brief visit to the Arfak Mountains of Irian Jaya. Dr. Patricia WOOLLEY was kind enough to donate a collection of *Xenobatrachus* from Lake Habbema in the central mountain ranges of Irian Jaya. The location of all these areas is shown in fig. 1. As a result of our studies we describe nine new species and are able to redefine two existing species.

MATERIALS AND METHODS

THE STUDY AREAS

The Arfak Mountains form an isolated range on the "Bird's Head" peninsula of extreme west New Guinea. A detailed description of the topography, climate and vegetation of the proposed Arfak Mountains Nature Reserve is given by CRAVEN & DE FRETES (1987). A description of the Lake Habbema area is given by ARCHBOLD, RAND & BRASS (1942).

The Eipo people of the Snow Mountains live on the northern slopes of the central mountain range, approximately 140°E and 4°26'S. Villages and gardens are situated between altitudes of 1600 and 2300 m, temperatures range from 12° to 23°C and the annual rainfall is approximately 6000 mm with a monthly mean between 370 and 670 mm (HOFFMANN & HOFFMANN, 1985). Within the cultivation zone there is much secondary vegetation and forest is restricted to higher altitudes.

Study areas in Papua New Guinea include (1) the basin of the Ok Tedi, an upper tributary of the south-flowing Fly River which rises in the Star Mountains, (2) the central mountains including the Schrader and Kubor Ranges and (3) the isolated Adelbert Ranges on the north coast. Despite the proximity of the Eipomek and Ok Tedi regions, little more than 100 km apart, they are very different climatically and topographically. Within the Ok Tedi area, land rises from 500 m at Tabubil to over 2000 m above the Hindenburg Wall, 15 km distant. Annual rainfall varies from 8000 mm at Tabubil to more than 9000 mm at Fubilan (2200 m). Monthly means at Tabubil range from 420 to 840 mm and from 600 to 870 mm at Fubilan. Settlement and cultivation are confined to the region between 1000 and 1800 m but population density is low and there is continuous rainforest throughout the re-

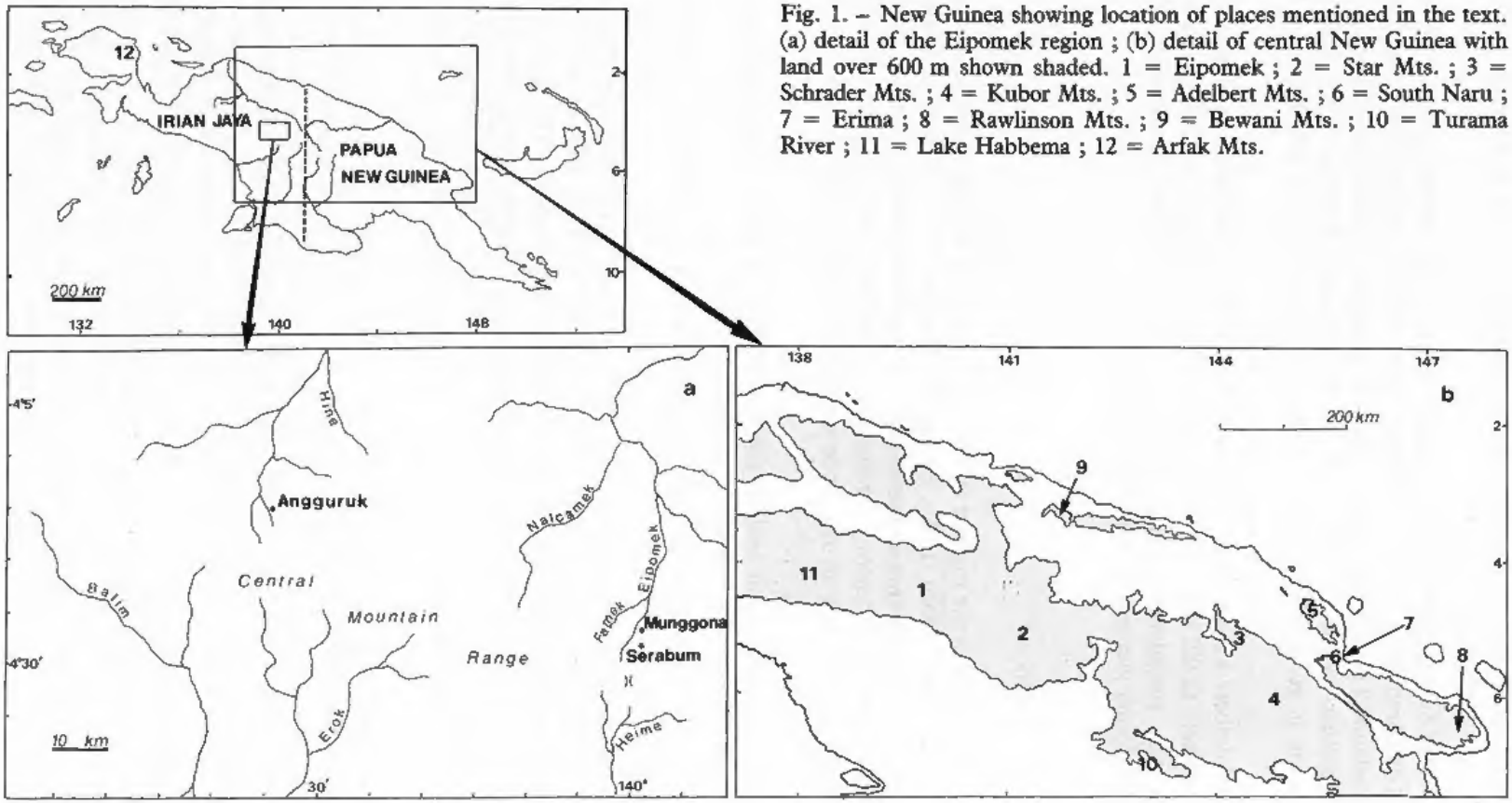

Fig. 1. – New Guinea showing location of places mentioned in the text. (a) detail of the Eipomek region ; (b) detail of central New Guinea with land over 600 m shown shaded. 1 = Eipomek ; 2 = Star Mts. ; 3 = Schrader Mts. ; 4 = Kubor Mts. ; 5 = Adelbert Mts. ; 6 = South Naru ; 7 = Erima ; 8 = Rawlinson Mts. ; 9 = Bewani Mts. ; 10 = Turama River ; 11 = Lake Habbema ; 12 = Arfak Mts.

gion. There is virtually no secondary grassland but at altitudes over 2000 m there are patches of boggy "alpine" vegetation known as "*terr*".

Collections in the Schrader and Kubor Ranges were made at altitudes around 1900 m where the natural mid-montane forest has largely been replaced by gardens, secondary vegetation and grassland. These areas are quite densely populated. Rainfall is seasonal and moderate and temperatures range from 10° to 25°. A detailed account of the upper Kaironk climate and vegetation is given by BULMER & TYLER (1968) and of the Elimbari area by DWYER (1975).

The isolated Adelbert Range rises to no more than 1500 m; rainfall is moderate and temperatures are unlikely to fall below 15° at any time. These mountains are rather sparsely populated and there are considerable areas of advanced secondary forest interspersed with new or recently abandoned gardens on very steep slopes.

METHODS AND ABBREVIATIONS

Measurements are taken in the manner of ZWEIFEL (1972) and include snout-vent length (SV), tibial length (TL), head width (HW), eye-nostril distance (EN), internarial distance (IN), eye diameter (EY) and tympanic diameter (TY). If necessary, examination of the roof of the mouth was accomplished by cutting through the ventral musculature on one side. We follow BURTON (1986) in referring to the bone on the roof of the buccal cavity as the "vomero-palatine".

The programme of discriminant analysis used for separating the component species of the *Xenobatrachus rostratus* complex was taken from DIXON (1983).

Specimens examined are retained in museum collections abbreviated in the text as follows:

AMNH: American Museum of Natural History, New York; MZB: Museum Zoologi, Bogor; PM: National Museum & Art Gallery, Port Moresby; RMNH: Rijksmuseum van Natuurlijke Historie, Leiden; SAM: South Australian Museum, Adelaide; UP: University of Papua New Guinea Biology Department; ZSM: Zoologische Staatssammlung, München.

RESULTS

THE VOICES OF *XENOBATRACHUS* SPECIES

At the time of writing, the advertisement call of only one species of *Xenobatrachus* had been recorded and described (*X. subcroceus*, MENZIES & TYLER, 1977). Current work enables description of seven more calls, one of which can be positively identified as that of *X. mehelyi*. On morphological grounds, the frogs responsible for four of the other calls can only be identified as *X. rostratus*. Further discussion on this species follows later.

All calls illustrated by sound spectrograms in figs. 2 and 3 and described in Table I were recorded in the field from frogs calling subterraneously, and it is clear from the uniformity of these calls that such a calling site with high ground level impedance imposes se-

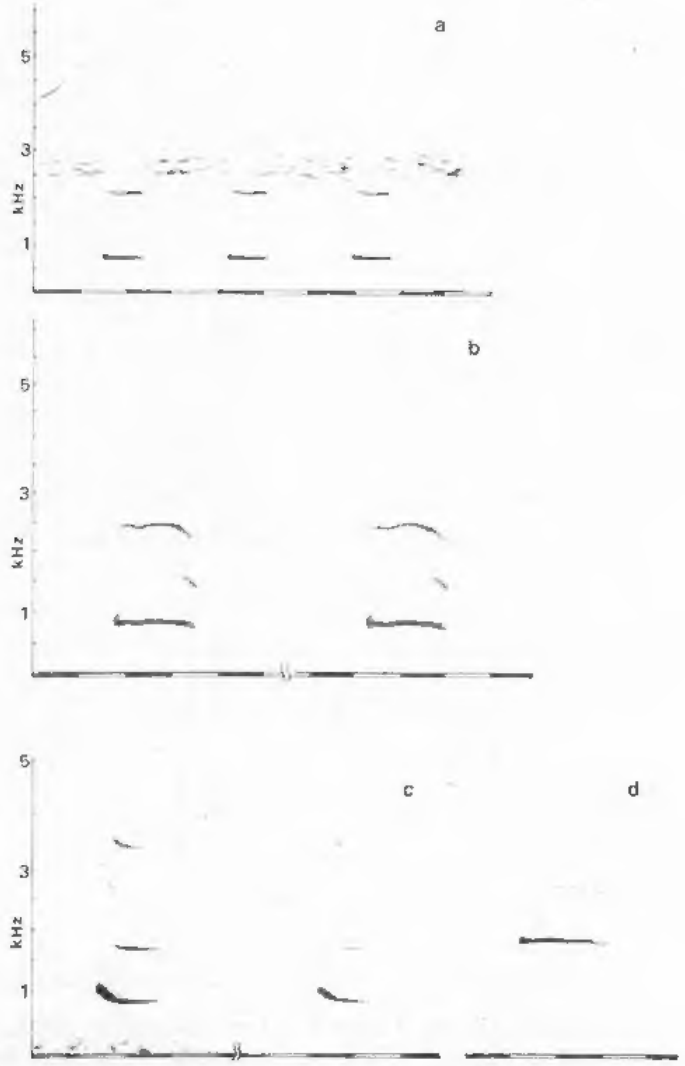

Fig. 2. – Sound spectrograms of calls of male *Xenobatrachus* spp. (a) *subcroceus* recorded near Lae ; (b) *mehelyi* recorded in the Ok Tedi valley ; (c) *anorbis* at 13° ; (d) *anorbis* at 17° on the Hindenburg plateau. Horizontal scale in 0.1 s intervals. All graphed with narrow (45z) filter.

vere restrictions on call parameters. General characteristics of *Xenobatrachus* calls which, incidentally, are similar to those of other fossorial species (MENZIES & TYLER, 1977) are a low fundamental and finely tuned frequency band, a well marked harmonic structure and short concise notes uttered, with one exception, in series. Essentially such a call consists of a series of notes of uniform length and interval giving an accoustic impression of a clear musical piping.

While in frogs in general there is a negative relationship between body size and calling frequency, in burrowing species there is a less obvious relationship (MENZIES & TYLER, 1977) and small frogs utter calls with similar frequency characteristics to larger ones. Differences between species are, therefore, more or less limited to note length and interval, but few species have been found to be sympatric so the possibility of interspecific confusion seems slight.

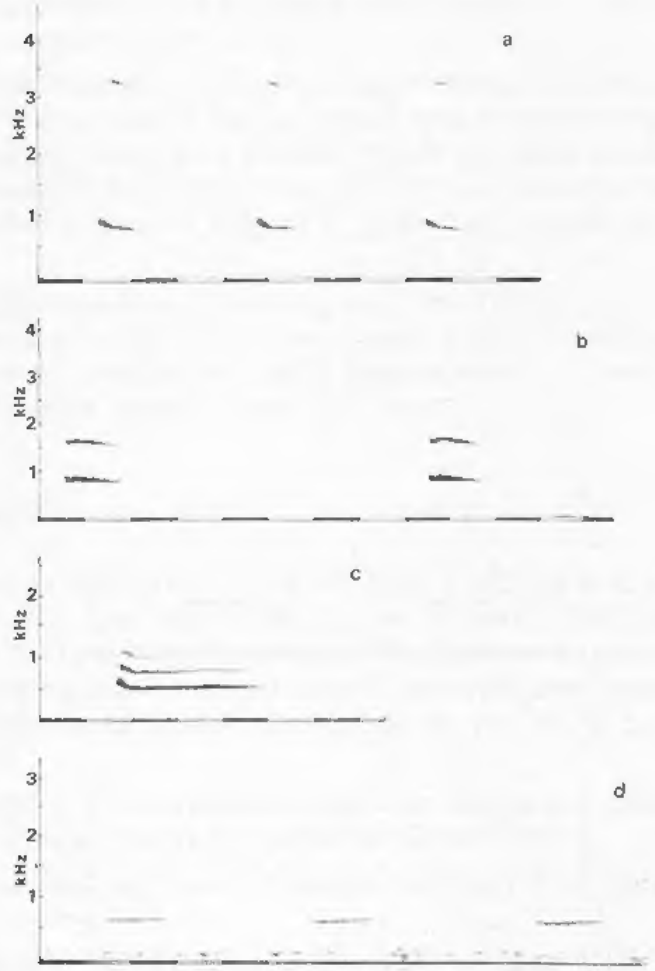

Fig. 3. – Sound spectrograms of calls of male *Xenobatrachus* spp. (a) *tumulus* in the Adelbert Mountains ; (b) *schiefenhoeveli* in the Eipomek Valley ; (c) *fuscigula* in the Kaironk Valley ; (d) sp. inc., South Naru. Horizontal scale in 0.1 s intervals. All graphed with narrow (45z) filter.

A note of caution should, perhaps, be introduced here. Many species of frogs, including several from New Guinea are known to make more than one kind of call and the possibility of *Xenobatrachus* also doing this cannot be ignored. However, there is nothing to suggest that the calls described here are anything other than long range advertisement calls.

The call of *Xenobatrachus subcroceus* has already been described but for comparative purposes we include a sound spectrogram of the call of this species (fig. 2a). There are 10 to 15 notes in the call, each is 0.06-0.07 s long and separated from the next by an interval of 0.15-0.29 s. The call of *mehelyi*, a species which could be confused with *subcroceus* on morphological grounds, is quite different (fig. 2b). Individual notes are twice as long and note intervals are much longer (about 1.5 s). Although no temperature data are available for the *mehelyi* recording and temperature may affect call parameters, it is unlikely that that could be responsible for the differences seen in figs. 2a and 2b. Evening temperature when the *mehelyi* recording was made was noted as being "very mild" (probably between 20 and 25°)

Table I. – Call parameters of *Xenobatrachus* species.

	subcroceus	*mehelyi*	*rostratus* group				
			South Naru	Adelbert	Hindenburg	Eipomek	Kaironk
Sample size	3	1	2	10	2	2	many
Notes per call	10-15	17	8-10	9-17	10	100	1
Note length (ms)	64-69	140	150	60-70	120	120	320
Note interval (ms)	154-285	1500	150	300-400	4-8 s	620	—
Dominant frequency (kHz)	0.4	0.8	0.6	0.9	0.8	0.6	0.5
Note repetition rate (min^{-1})	300	36	180	210	12-13	81	—
Ambient temperature (°C)	27-28	"mild"	24*	19	13-17	—	—

* Ambient temperature in general region of the recordings, no voucher specimens.

and a maximum depression of 7°C is unlikely to have slowed note repetition rate by a factor of ten.

Spectrograms 2c to 3c display calls of short-legged *rostratus*-like frogs. Fig. 2c displays a call recorded at Finimterr, 2100 m, on the Hindenburg Plateau. This has the slowest note repetition rate (12 notes per minute) but was also recorded at the lowest temperature, 13.3°. However, a similar call (fig. 2d) was recorded on the previous day when the temperature was 17° and the calling rate was no different. Apart from minor changes in frequency, the most noticeable difference seems to be a shift in emphasis from the 1st to 2nd harmonic. Fig. 3a displays a call recorded in the Adelbert Mountains at 1500 m and a ground temperature of 19.1°. This call shows a fast repetition rate approaching that of *subcroceus* at 27° but the fundamental frequency of *subcroceus* is lower. Fig. 3b depicts a call recorded in the Eipomek Valley, altitude 1800 m. Note characteristics are similar to the Adelbert call but the repetition rate is slower. However, this call contains more than 100 notes and so is seven times longer than that from the Adelbert site. No temperature data are available for this call.

Fig. 3c is a single note call recorded in the Kaironk valley at 1800 m. The note length is twice that of any other call shown here and the accoustic impression is quite different. Finally, fig. 3d displays a *Xenobatrachus*-type call recorded at South Naru, very close to the type locality for *Xenobatrachus rostratus*. Unfortunately no frog could be associated with this recording.

The diet of *Xenobatrachus* and *Xenorhina* species

The advantage of a fossorial existence, in terms of an under-exploited environment, has been discussed by Menzies & Tyler (1977), but discussion was confined to the benefits of a humid environment with abundant potential prey in the form of invertebrate fauna. Little study has been carried out on the diet of microhylid frogs in general or on asterophryine microhylids in particular and it has often been supposed that these small-mouthed frogs are restricted to a diet of ants. Parker (1934) refers to a "widespread impression that (the Microhylidae) is predominantly a cryptozoic, myrmecophagous group" though Zweifel (1972) wrote that "the asterophryines do not conform to the view that microhylids are predominantly eaters of ants and termites". However, the only positive evidence for diet in any *Xenobatrachus* or *Xenorhina* species is recorded by Brongersma (1954), Tyler (1963) and Zweifel (1960) where it was stated that examples of *Xenobatrachus obesus*, *Xenobatrachus rostratus* and *Xenorhina oxycephala* had consumed earthworms and Van Kampen (1913), writing of *Xenobatrachus bidens*, "the stomach contained ants".

Access to a large collection of *Xenobatrachus* species has allowed a more exhaustive investigation into the diet of these frogs and 40 individuals of 13 species were opened in order to examine their stomach contents, if any. Only 20 of them had anything in their stomachs. The others were empty, possibly an artifact due to time elapsing between capture and preservation. In those examples with empty stomachs the contents of the rectum were examined instead.

In only three cases were recognizable arthropod remnants found. These exceptions included one of three *Xenobatrachus obesus* in which a single ant exoskeleton was found among the rectal contents, one of five *Xenobatrachus ocellatus* which contained a newly ingested cen-

tipede approximately 20 mm long and one of three *Xenobatrachus arfakianus* which contained a small beetle and remains of a centipede. Since insect remains, and especially the head exoskeletons of ants, are resistant to digestion and are easily recognizable in the faeces of insectivorous animals, the absence of such remains in the stomach and rectal contents must surely indicate that insects are not a regular part of the diet.

Four stomachs (in examples of *X. fuscigula, mehelyi, multisica* and *schiefenhoeveli*) contained recently ingested earthworms. In one case, a *X. fuscigula* of body length 32 mm had ingested an earthworm 90 mm long and 3.8 mm diameter. Clearly small mouth size places little restriction on the ingestion of earthworms.

Several stomachs which contained no macroscopically recognizable animal material revealed earthworm chaetae when the contents were examined microscopically. Two stomachs contained pieces of acellular membrane thought to be earthworm cuticle, several others contained pieces of pavement epithelium which could be earthworm epithelium but neither of these could be confirmed by examination of earthworm tissue. One stomach (*X. tumulus*) contained a mass a fungal tissue.

All rectal and stomach contents included large quantities of plant detritus and sparse mineral grains, suggestive of humus-laden soil. Earthworm chaetae, easily recognized when whole, were found in many cases but were not as abundant as expected, if they were to pass through the gut undamaged. It is possible that all this plant material had been ingested in the course of eating animal prey but we are more inclined to believe that this represents the gut contents of digested earthworms.

In conclusion, the very low occurrence of recognizable arthropod remains, the presence of earthworms in four stomachs and of earthworm chaetae in both stomach and rectal contents of most of the others examined and of large quantities of vegetable detritus in all specimens leads us to believe that these are specialized earthworm-eating frogs. Absolute size seems to have no influence on diet, *Xenobatrachus obesus* at 70 mm is one of the largest species, *X. fuscigula* at 26 mm, one of the smallest. In general terms, the dietary regime of all these frogs appears to be the same. Perhaps these frogs are the ecological equivalent of the worm-eating limbless amphibians, Gymnophiona, which are absent from the New Guinea region but present in the more western parts of the Indo-Australian archipelago.

THE VOMERO-PALATINE SPIKES AND THE TONGUE

The function of the backwardly directed vomero-palatine spikes, which are characteristic of *Xenobatrachus* but not of *Xenorhina*, does not appear to have been the subject of previous comment. These spikes, one, two or three in number, are downwardly and backwardly directed extensions of the vomero-palatine bones and one is shown in vertical section in fig. 4. They lie behind the internal nares and are completely covered by the continuous mucosa of the buccal cavity, a fact noted by MÉHELŸ (1898) in his original description of *Choanacantha rostrata*. They are, in fact, no different in structure from the vomerine "teeth" present in very many species of frogs, except that they are very much bigger.

Vomerine teeth are believed to assist in retaining food in the mouth and directing it toward the gullet but it is difficult to see how the single (or double) enlarged spikes of

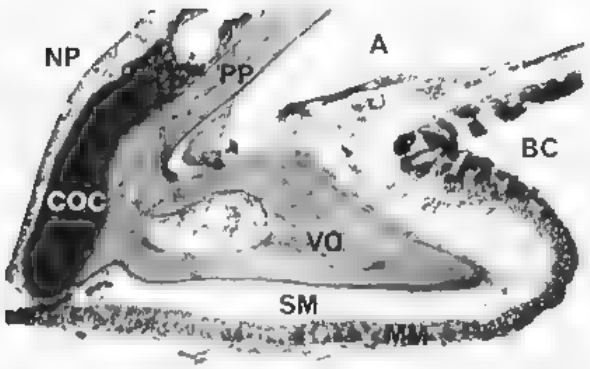

Fig. 4. – Vertical section through the vomero-palatine spike of *Xenobatrachus fuscigula*. The gap between palatine bone and the mucosa below, marked A, is an artifact of preparation. BC = buccal cavity ; COC = cartilage of the olfactory capsule , MM = mucous membrane ; NP = nasal passage ; PP = palatine-prevomer ; SM = submucosa ; VO = vomerine odontoid.

Xenobatrachus could be any more efficient than a battery of smaller teeth. We simply suggest that they serve to orientate earthworms head-first in the buccal cavity and direct them towards the gullet.

The upper surfaces of the tongues of *Xenobatrachus* and *Xenorhina* were noted by Burton (1983 and 1986) to differ from those of other asterophryine microhylids in that they bear "deep longitudinal striae" said to "vastly increase the glandular surface of the tongue". A detailed account of the structure of the tongue is out of place here but an explanation for the characteristic appearance is needed. The tongue of *Xenobatrachus ocellatus*, for instance (fig. 5), as in all asterophryine microhylids, is not protrusible but is anchored to the floor of the buccal cavity leaving only the lateral margins free. These margins are muscular and can be inrolled forming, together with the roof of the buccal cavity, a longitudinal tube. The central, "fixed", part of the tongue contains vertical and longitudinal rows of ductless multicellular glands lined with large-nucleate, cuboid secretory cells. These more or less spherical glands are stacked one upon the other and release their contents by rupture, with the upper ones releasing secretions in sequence while compartments below are still actively secreting. Thus there are vertical columns of glandular compartments actively secreting at the base and

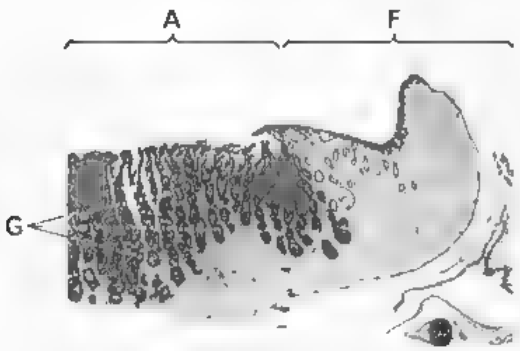

Fig. 5. – Transverse section through the tongue of *Xenobatrachus ocellatus*. A = central, attached portion ; F = free margin ; G = vertical columns of glands.

rupturing at the surface. It is the parallel arrangement of these erupting glands that is responsible for the grooved appearance of the surface of the tongue.

We cannot, at this time, suggest any way in which these peculiar glands are an adaptation to a particular diet.

SYSTEMATIC ACCOUNT

The **Xenobatrachus rostratus** group

Material examined (number of specimens in parentheses). – Lake Habbema, 2800 m (10) ; Eipomek, 1800 m (11) ; Star Mountains, 1800-2100 m (2) ; middle Kaironk Valley, Schrader Mountains, between 1300 and 2000 m (9) ; Lower Kaironk Valley, 1300 m (7) ; Elimbari, Kubor Mountains, 1900 m (3) ; Adelbert Range, 1500 m (3) ; Bewani Mountains (3) ; Rawlinson Range, 1600-2150 m (10) (fig. 1).

Discussion. – ZWEIFEL (1972) has pointed out some of the problems associated with this "species" and called attention to the presence of three forms, with morphological and geographical integrity, within the material that he examined. At that time, no call data were available to support division of the sample into more than one species and a further difficulty concerned the identity of "true" *rostratus* as the syntypes were reported to have been destroyed (ZWEIFEL, 1972 : 523). Call data are now available for five populations, and, when calls are considered together with morphological differences, one is left with the choice of regarding *Xenobatrachus rostratus* as one highly polymorphic species or a group of closely related species. Therefore we opt to designate a neotype for *Xenobatrachus rostratus* and redefine it and describe the other populations (other than *Xenobatrachus ocellatus*) which we include in this group as new species.

Dimensions of the total sample of *Xenobatrachus rostratus*, sensu lato, were entered into a discriminant analysis programme (DIXON, 1983) and a sample of *Xenobatrachus subcroceus*, a species of comparable size but readily distinguished by its much longer legs, was included as an "outgroup". Of the eight groups entered in the analysis, those from the Schrader and Kubor Mountains came out as insignificantly different so these two groups were combined and the analysis repeated. All variables except SV and HW contributed significantly to the analysis and the results are shown in fig. 6. All clusters are significantly distinct ($p<0.05$). The "out-group", *subcroceus*, is distant from all others but not more so than clusters within the *rostratus* group are from one another. The calls of the Adelbert and Eipomek populations also show more similarity to one another than to any of the others. The call of the central highland (Schrader & Kubor mountains) population, consisting only of a single note, supports the morphological distinctiveness of this population. The upper Fly specimen also has a distinct call, although it was recorded at a lower temperature, which may be partly responsible for the slow note repetition rate. No call data are available for the relatively low altitude population from the lower Kaironk valley but ZWEIFEL (1972) pointed out morphological similarities between this population and coastal specimens which he examined.

Thus morphological and call data show that the total sample of "*rostratus*" includes at least five distinct species. Which of these is the true *rostratus*? Unfortunately, loss of the syn-

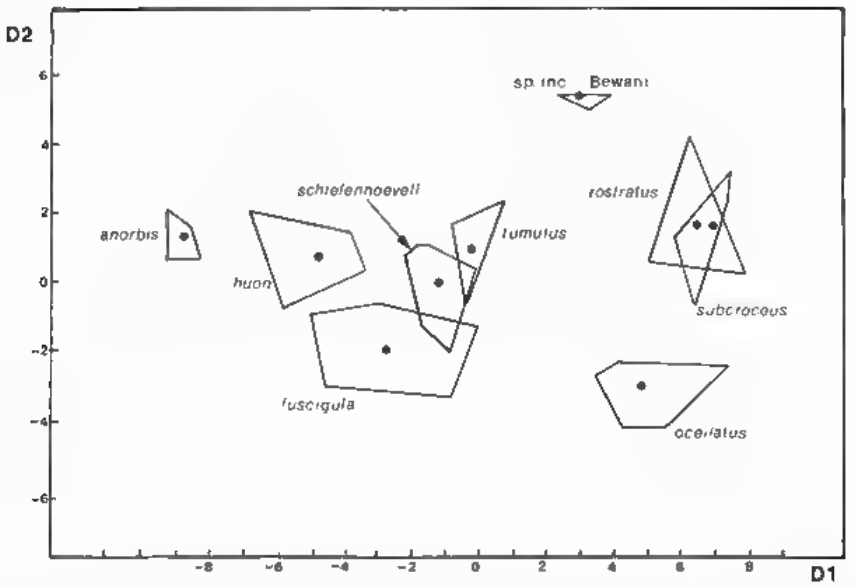

Fig. 6. – Discriminant analysis of members of the *Xenobatrachus rostratus* group of species together with *Xenobatrachus subcroceus*. D1, D2 are 1st and 2nd discriminant axes. All groups are significantly distinct at $p<0.01$ except *schiefenhoeveli-tumulus* where $p<0.05$. NB : this is a two dimensional representation of a multidimensional figure. The apparent proximity of some groups is an artifact of presentation.

types of that species and lack of topotypic material hinders comparison. However the call graphed in fig. 3d, recorded at South Naru less than 12 km from the type locality at Erima, is distinct from all the others. Although this call is unsupported by a voucher specimen, we believe that there is now sufficient evidence to relate the lowland population to the name *rostratus* and to differentiate the other populations as distinct species. Since there are no available names in the literature, the central highland, Star Mountains, Eipomek, Adelbert and Rawlinson populations are described as new species. Lack of knowledge of intra-specific variation in these species hinders recognition of the three specimens from Bewani for which no call data are available. These are left unnamed pending acquisition of more data.

General diagnosis. – Members of the *rostratus* group may be distinguished from all other *Xenobatrachus* species by a combination of small size (SV less than 47 mm), single palatine spike, short legs (maximum TL/SV 0.39) and small eyes (maximum EY/SV 0.074).

Xenobatrachus rostratus (Méhelÿ, 1898)

Choanacantha rostrata Méhelÿ, 1898 : 175. – Type locality : Erima, Astrolabe Bay, Madang Province of Papua New Guinea. This is probably not the present-day settlement and agriculture station on the coast, known in German colonial times as Erimahafen, but the village several kilometres inland shown on the map in Hahl (1980).

Neotype (designated herein). – UP 1926, collected by R. Jackson in the lower Kaironk valley, altitude 1300 m, Madang Province of Papua New Guinea, in 1968.

Other material examined. – UP 1063, 1920, 1922, 1924-5, 1929, Lower Kaironk Valley, 1300 m, Madang Province of Papua New Guinea.

Diagnosis. – *Xenobatrachus rostratus* may be distinguished from all other members of the *rostratus* group by a combination of larger size (minimum SV 39, maximum 46.5 mm), longer legs (minimum TL/SV ratio 0.31, mean 0.33), smaller eyes (maximum EY/SV ratio 0.059, mean 0.056) and narrowly placed nostrils (EN/IN minimum 1.11).

Description of the neotype. – Dimensions : SV 44.28 ; TL 15.15 ; HW 16.26 ; EN 2.83 ; IN 2.29 ; EY 2.55 ; TY 2.93.

Body rotund, head scarcely distinct from the body, flattened, triangular; snout rounded-truncate, projecting; canthus rounded, lores very oblique, slightly concave; nostrils closer to the tip of the snout than to the eyes and close to each other (EN/IN 1.24) ; eyes small (EY/SV 0.057) ; distinct supratympanic fold present ; a single spike present on each vomero-palatine.

Arms short, fingers not to scarcely dilated at the tips, 3>4>2>1; legs short (TL/SV 0.34), toe tips slightly dilated.

Skin smooth but with several longitudinal rows of raised warts. Dorsal colour (in preservative) medium dull brown with a faint, thin, middorsal light line; supratympanic fold dark; ventral all over dull brown spotted with white; posterior sides of the thighs somewhat darker. There is no information on the colour in life.

MÉHELŸ's original description is detailed but gives no measurements, other than overall length (39 mm). In selecting a neotype, a specimen from as close to the type locality as possible is desirable, as well as one that matches the original description. There are two problems here. In the 100 years that have elapsed since MÉHELŸ's specimen was collected there is considerably less forest around Erima than there was. We have no doubt that the species still occurs in the forested hill slopes behind the village but failed to collect any there. The second problem concerns MÉHELŸ's original description and illustration of the holotype. The illustrations show a frog with a "pinched-in" head, vertical lores and a rounded projecting snout, apparently unsupported by any skeletal elements. This head shape is markedly different from that of any *Xenobatrachus* known to us. Such a snout shape is known in *Choerophryne rostellifer* (a microhylid) and in several *Litoria* species but not in any asterophryine microhylid. We can only assume that this peculiarity was an artifact of preservation.

Variation. – Critical dimensions and ratios for other available material are given in Table II and graphed in fig. 7. Development of disks on the toes is illustrated in fig. 8a.

Dorsal colour tan, vaguely mottled, or plain or mottled dark brown; several longitudinal rows of dark warts and a faint thin mid-dorsal line nearly always visible; a fold of skin, contrastingly dark in colour, running from the posterior corner of the eye, above the tympanic membrane and ending at the arm insertion. Upper lip and tip of the snout pale; ventral surface pale, mottled all over to a varying degree (one almost without mottling, one dark all over but with scattered light spots); chin dark mottled but throat not different from the rest of the ventral surface; the posterior sides of the thighs and cloacal region dark, distinct from the dorsal colour; throat never uniformly dark.

The colour in life is unknown to us but it is probable that the ventral surface is reddish or orange. ZWEIFEL (1972) reports one specimen from Wewak which was bright red beneath.

Distribution. – ZWEIFEL (1972) notes examples of the "lowland form" from the north-east corner of Irian Jaya and Wewak while the type locality, Erima, lies on the coast some 320 km further east. Together with the lower Kaironk examples this gives an altitudinal range from sea level to 1300 m.

Table II. – Critical dimensions and ratios (mean and range) for some *Xenobatrachus* and *Xenorhina* species.

Xenobatrachus	SV (mm)	TL/SV	EN/IN	EY/SV	n
anorbis[1]	22.5 (21.3-23.4)	0.29 (0.28-0.30)	1.28 (1.25-1.32)	0.063 (0 051-0.073)	4
arfakianus[2]	48.7 (48.4-48.8)	0 40	1 04 (0.95-1.12)	0.070 (0 069-0.071)	2
fuscigula	31.7 (26.5-37.8)	0 30 (0.26-0.34)	0 98 (0.95-1.12)	0.060 (0 050-0.068)	13
*giganteus**	83.6 (79.8-90.2)	0 35 (0.33-0.36)	0.97 (0.97-1.17)	0.060 (0.050-0.070)	3
huon[3]	30.1 (28.1-32 9)	0 28 (0.26-0.30)	1.19 (1.09-1.35)	0.065 (0.059-0.071)	10
*huon**[4]	31.2 (20.0-41.7)	0.26 (0.23-0.33)	1.27 (1.00-1.47)	0.074 (0.064-0.084)	60
multisica	51.5 (41.9-74.3)	0.39 (0.35-0.45)	1.08 (0.82-1.31)	0.060 (0 047-0.070)	24
*ophiodon**	27.3 (24.8-28.1)	0.51 (0.49-0.52)	0 80 (0.72-0.90)	0.093 (0.090-0.100)	3
rostratus	44.0 (41.1-46.5)	0.33 (0.31-0.38)	1.18 (1.10-1.35)	0.056 (0.051-0.059)	7
scheepstrai	50.0 (48.4-51.5)	0.49 (0.47-0.51)	1.00 (0 89-1.11)	0.060	2
schiefenhoeveli	28.2 (26.7-30.7)	0 34 (0.31-0 36)	1.22 (1 04-1.33)	0.070 (0.065-0.074)	10
tumulus	27.1 (26.8-27.7)	0.38 (0.38-0.39)	1.22 (1.11-1.28)	0.065 (0.058-0.074)	3
Xenorhina					
eiponis	35.1 (23.0-34.6)	0.50 (0.48-0.52)	1.10 (1.03-1.16)	0.081 (0.070-0 087)	6
minima	28.5 (23.0-34.6)	0.32 (0.30-0.33)	0.84 (0.70-1.02)	0.069 (0.054-0.078)	9

[1] Paratype RMNH 23513 omitted due to its poor condition. – [2] Adult holotype and paratype only. – [3] Type series only. – [4] Data from ZWEIFEL (1972). – * entries include data from ZWEIFEL, 1972.

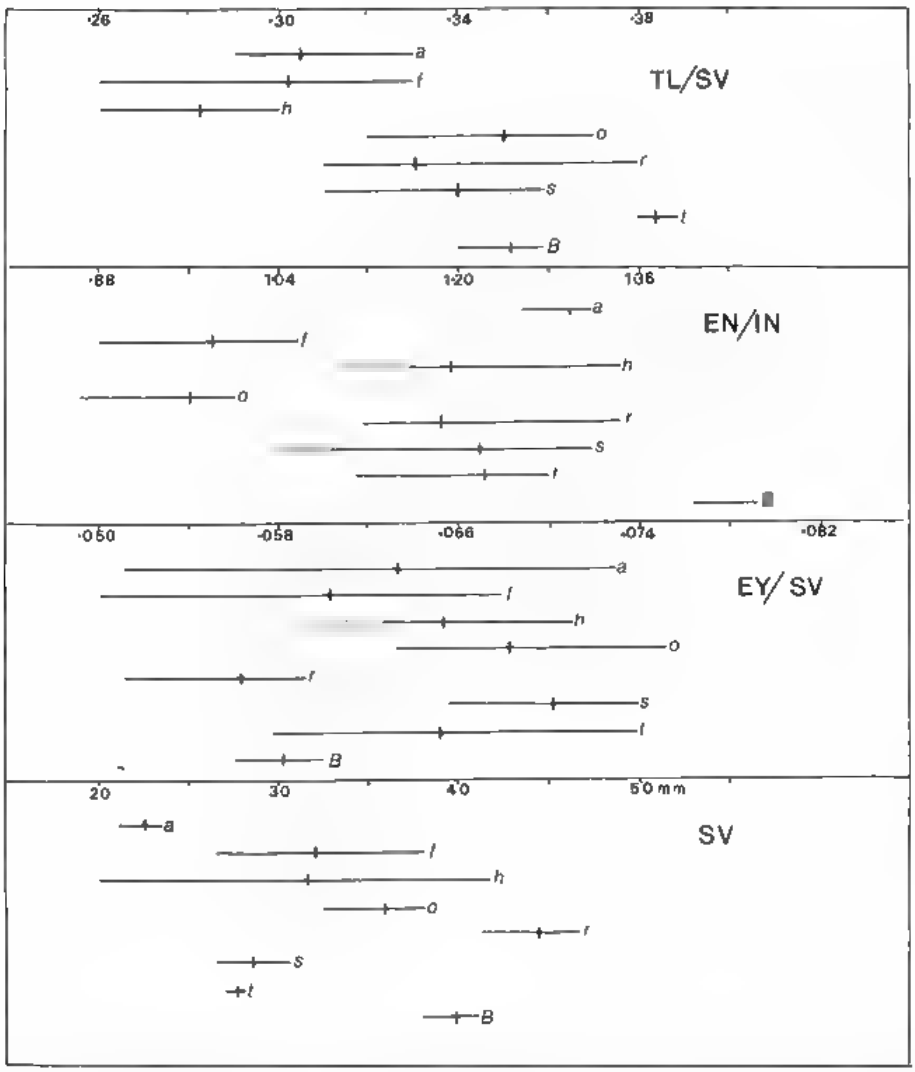

Fig. 7. – Comparative sizes and ratios of members of the *Xenobatrachus rostratus* group of species a = *anorbis* ; f = *fuscigula* , h = *huon* ; o - *ocellatus* ; r = *rostratus* ; s = *schiefenhoeveli* ; t = *tumulus* ; B = sp. inc., Bewani Mountains. SV = snout-vent length ; TL = tibial length ; EN = eye-nostril distance ; IN = internarial distance ; EY = eye diameter.

Comparison with other species. – This is a lowland and lower montane species and so is sympatric with *fuscigula* in the northern foothills of the central ranges and possibly with *tumulus* and *subcroceus* in the foothills of the Adelbert and Finisterre Ranges. Within the *rostratus* group, this species is best distinguished by a combination of larger size and smaller eyes. Outside that group, the characters given in the general diagnosis will suffice.

Discussion. – The problem of relating this population to the non-existent syntypes of *rostratus* has already been mentioned. ZWEIFEL (1972) points out the morphological similarity of the lower Kaironk population to other lowland examples which he examined; the larger size seems to be the most obvious unifying character. No call data are available for the lower Kaironk population but the call depicted in fig. 3d, unfortunately not supported by a voucher specimen, is sufficiently different from the other calls graphed in that figure.

Fig. 8. – Left hind feet (ventral view) of *Xenobatrachus* spp (a) *rostratus* ; (b) *anorbis* ; (c) *fuscigula* ; (d) *schiefenhoeveli* ; (e) *tumulus*.

Xenobatrachus anorbis new species

Holotype. – UP 5621, adult male, collected by J.I. MENZIES and D. H. HYNDMAN in January 1985 at Finimterr on the Hindenburg plateau of the Star Mountains at an altitude of 2100 m, Fly River Province of Papua New Guinea.

Paratypes. – PM 2354a-c, collector and provenance unknown; RMNH 23513 (formerly 16619), collected by the 1959 Netherlands New Guinea Expedition at Tenmasigin, Star Mountains, altitude 1900 m. This specimen was discussed by ZWEIFEL (1972 : 529) but left unassigned to species.

Etymology. – From the latin "an", without and "orbis", a disk.

Vernacular name. – "*Niengu*" (Wopkaimin).

Diagnosis. – A combination of very small size (maximum 21.3 mm in the five specimens

known), short legs (TL/SV 0.29-0.32), a high EN/IN ratio (1.26-1.32), large eyes (EY/SV 0.073-0.082) and complete lack of digital disks distinguish this species.

Description of the holotype. – Dimensions : SV 21.34 ; TL 6.20 ; HW 7.40 ; EN 1.57 ; IN 1.25 ; EY 1.56 ; TY 1.83.

Body rotund, head scarcely distinct from the body, tapering, snout rounded, projecting; canthus rounded, lores oblique, slightly concave; nostrils close to tip of snout and close to each other (EN/IN 1.26); eyes comparatively large (EY/SV 0.073); tympanic membrane distinct, no supra-tympanic fold; limbs short; fingers without disks, 3>4>2>1; legs very short (TL/SV 0.29); toes without disks (fig. 8b), tapering at the apices and with scarcely any trace of grooving; palatine spikes single, comparatively large and pointed.

Dorsum plain dark brown (dull grey-brown in life) without marks other than a faint mid-dorsal line bifurcating posteriorily and running down the backs of the thighs. Skin somewhat rugose but without the longitudinal rows of warts seen in other species. Ventral surface plain white (dull orange in life) with a faint mid-ventral line, heavily dark speckled on the throat.

Variation. – Variation in size and ratios is given in Table II.

The three paratypes (PM 23540c-e) are similar in colour to the holotype, the fourth (RMNH 23513) is in poor condition with the digits damaged and is much smaller, presumably immature.

Ecological note. – The holotype was collected near Finimterr, an open boggy area in the midst of mid-montane forest. It was calling throughout the day and eventually was uncovered below several centimetres of leaf litter, roots and soil. Others were heard calling in the forest along the track leading away from Finimterr, but none were heard calling at lower altitudes. The call (fig. 2c,d) consists of a series of notes at lengthy intervals.

Distribution. – Known only from the Star Mountains of central New Guinea (fig. 1).

Comparison with other species. – In that it has very short legs and a dark throat, this species is most akin to *fuscigula*, but differs as it is much smaller, has more narrowly placed nostrils (EN/IN 1.26 compared to a maximum of 1.06) and larger eyes (EY/SV 0.073 compared to a maximum of 0.068). Also the call is a series of notes, not single, longer, notes. It differs from all species except *ocellatus* and *schiefenhoeveli* in that toe disks are completely absent.

At lower altitudes it may be sympatric with *mehelyi* which has much longer legs.

Xenobatrachus fuscigula new species

Holotype. – UP 3342, collected in January 1972 by R.N.H. BULMER in the upper Kaironk Valley, Madang Province of Papua New Guinea at an altitude between 1300 and 2000 m.

Paratypes. – UP 3239-44, 3246, 5014-5, collected by R.N.H. BULMER and J.I. MENZIES at the type locality; UP 3440-2, collected by J.I. MENZIES on Mount Elimbari, Simbu Province of Papua New Guinea, around 2000 m.

Etymology. – From the latin "fuscus", dark and "gula", the throat.

Vernacular name. – "*Gwnm*" (Kalam) also applied to other squat, short-legged microhylid frogs.

Diagnosis. – Distinguished from other members of the *rostratus* group by small size (maximum SV in the type series 36.6 mm but ZWEIFEL, 1972, extends the maximum to 42 mm in his larger sample), very short legs (maximum TL/SV 0.33, mean 0.30), low EN/IN ratio (maximum EN/IN 1.06, mean 0.98), dark throat and call consisting of a single long note.

Description of the holotype. – Dimensions : SV 32.02 ; TL 9.06 ; HW 11.86 ; EN 1.73 ; IN 1.82 ; EY 1.87 ; TY 2.19.

Body obese, head small and not distinct from the body; snout rounded and projecting; without angular canthus; nostrils nearer to the tip of the snout than to the eye and further from each other than from the eyes (EN/IN 0.95); eyes small (EY/SV 0.058); tympanic membrane conspicuous, slightly larger than the eye.

Limbs short; fingers short without expanded disks though the apices are demarcated by horizontal grooves, 3>4>2>1; toes moderately short and with small disks (fig. 8c), 4>3>5>2>1; no subarticular or metatarsal tubercles.

Dorsal colour tan with four longitudinal rows of dark warts; slightly darker on head and mid-dorsal region; ventrum pale with irregular dark reticulation; throat entirely dark; cloacal region and posterior thighs dark.

Variation. – Critical dimensions and ratios are given in table II and graphed in fig. 7.

The colour in life of the larger specimens was pinkish-brown dorsally with faint, thin, mid-dorsal lines that bifurcate and continue down the posterior sides of the thighs. Small specimens were darker, some almost black. The flanks were speckled grey and the ventral surface yellow with a varying amount of dark mottling; three specimens were entirely dark on the ventral surface. The throat was invariably uniformly dark. ZWEIFEL (1972 : fig. 71) illustrated pattern variation in three examples of this species from the Kaironk Valley.

The three specimens from Elimbari are, in alcohol, uniform pale tan above but differ from the Kaironk material in that the cloacal "patch" is not so dark and the throat, while more heavily mottled than the rest of the ventrum is not uniformly dark. All three specimens have mid-dorsal and mid-ventral lines.

This species is illustrated in colour in MENZIES (1975 : plate 9d, labelled *Xenobatrachus rostratus*) and in monochrome in ZWEIFEL (1972 : fig. 68, also labelled *rostratus*).

Distribution. – The Schrader, Hagen and Kubor Ranges and the Sepik-Wahgi Dividing Range of central New Guinea, between 1300 and 2900 m.

Ecological note. – This species is common throughout the lower and mid-montane zones of the central highlands of Papua New Guinea. These include intensively cultivated zones but the frogs seem as common in cultivated areas as in forest. The call of the male is a single mournful note uttered from below ground spasmodically throughout the day. The species appears to be entirely fossorial.

Comparison with other species. – This species most closely resembles *anorbis* from the Star Mountains and at lower altitudes it is probably sympatric with *rostratus*; differences are discussed in the accounts of those species.

Xenobatrachus huon new species

Holotype. – UP 7431 (formerly AMNH 76097), adult female, collected by H.M. VAN DEUSEN and S.O. GRIERSON in the upper Kua River valley, Rawlinson Mountains, Morobe Province, Papua New Guinea between 1630 and 2130 m, in July 1964.

Paratypes. – UP 7424-7430, 7432-7433, collected with the holotype.

Etymology. – Named for the Huon Peninsula of New Guinea which includes the Rawlinson Mountains.

Diagnosis. – Distinguished from all other species in the *rostratus* group by a combination of very short legs (TL/SV between 0.26 and 0.30), narrowly placed nostrils (EN/IN between 1.09 and 1.35) and larger eyes (EY/SV 0.059-0.071).

Description of the holotype. – Dimensions : SV 28.34 ; TL 8.56 ; HW 10.89 ; EN 2.01 ; IN 1.78 ; EY 1.81 ; TY 1.93.

Body obese, head narrow and pointed, slightly constricted from the body, rounded, truncate in profile and from above; lores oblique and almost flat; eyes moderately large (EY/SV 0.064); nostrils nearer to the tip of the snout than to the eye and close together (EN/IN 1.13).

Fingers short, rounded at the apices but without distinct disks; toes moderately long, slightly expanded at the apices; no articular or metatarsal tubercles.

Skin smooth, dorsum dark brown but spotted all over with darker brown, slightly paler on the flanks; ventrum whitish spotted all over with brown; no dorsal or ventral stripes and no inguinal ocelli.

Variation. – ZWEIFEL (1972) has given a detailed description of these specimens which originally formed part of a much larger series (about 60 frogs), all from the type locality, and there is nothing to add in the current account. Differences in body ratios between the present account and that of ZWEIFEL can be ascribed to the difficulty of obtaining accurate measurements in preserved specimens. There is no information on the colour in life.

Ecological notes. – A detailed description of the country around the type locality is given by VAN DEUSEN (1978). All specimens were detected during the daytime, by their calling, and dug out of the humus layer.

Distribution. – Only known from localities between 1300 and 2000 m in the eastern Huon Peninsula mountains.

Comparison with other species. – No other species of the *rostratus* group are known to occur in the mountains of the Huon Peninsula. This species appears closest to *fuscigula* of the central mountains in that it shares very short legs but the EN/IN ratio is higher and without overlap. The eyes are larger on average and the dark throat, characteristic of *fuscigula*, is absent. *Xenobatrachus subcroceus* is known from the foothills at the south-eastern end of the Huon mountains and *X. rostratus* from foothills at the north-western end but there is no altitudinal overlap anywhere. *Xenobatrachus huon* thus appears to be completely allopatric to all other species.

Xenobatrachus schiefenhoeveli new species

Holotype. – UP 7399, adult female with well developed ova, collected by J.P. BLUM between April and June, 1976 at Munggona in the Eipomek Valley of Irian Jaya, Jayawijaya Division, altitude 1800 m.

Paratypes. – AMNH 128237-8, MZB 2801, UP 5681-2, ZSM 104/87a-c, collected by J.P. BLUM with the holotype.

Vernacular name. – "*Durukor*" (Eipo).

Etymology. – Named for Wulf SCHIEFENHOEVEL, field director of the Eipomek expeditions.

Diagnosis. – Distinguished from all other species in the *rostratus* group by a combination of small size (SV 31 mm), longer legs (TL/SV between 0.31 and 0.36), narrowly placed nostrils (EN/IN mean 1.22), larger eyes (EY/SV minimum 0.065, mean 0.070) and a call consisting of a very long series of notes.

Description of the holotype. – Dimensions : SV 29.44 ; TL 9.17 ; HW 8.76 ; EN 1.78 ; IN 1.41 ; EY 2.18 ; TY 1.35.

Body obese; head narrow, slightly constricted from the body; snout projecting, rounded in profile and from above; canthus rounded, lores oblique and almost flat; eyes comparatively large (EY/SV 0.074); nostrils nearer to the tip of the snout than to the eye and close together (EN/IN 1.26); tympanic membrane rather indistinct.

Fingers short, without disks or tubercles; legs short (TL/SV 0.31), toes moderately long, virtually without disks (fig. 8d) although the apices are slightly wider than the penultimate phalanges and are demarcated by horizontal grooves; no subarticular or metatarsal tubercles.

Skin smooth; mottled dull brown above, more greyish on head and limbs, paler on the flanks and with a broken transition to the ventral creamy colour. Venter vaguely reticulated with brown, more densely on the throat and limbs; parts of the thighs concealed at rest not coloured differently; no inguinal ocellus or mid-dorsal stripe.

Variation. – Critical dimensions are given in table II and graphed in fig. 7. The paratype series is remarkably uniform in colour with virtually no variation. The colour in life is shown in fig. 9a.

Ecological notes. – This common species occurs in open grassland or rocky places with moss and fern vegetation, they were never found nor heard in forests. They were never seen on the ground surface but are located by their calling and found below moss or vegetation.

Males call by day, especially during sunny periods and calls are spaced 8 to 10 minutes apart. Each call consists of a very long series of notes (more than 100) at approximately 0.75 s intervals (fig. 3b); each note has a length of 0.1 s and a well marked harmonic structure with a dominant frequency of 1 Hz. The frog which made the call graphed in this figure was found amongst grass roots. The acoustic impression is of a clear musical piping.

Distribution. – Known only from the type locality (fig. 1).

Comparison with other species. – In most morphological features the Eipomek population comes closest to that from the Adelbert Range and in fig. 6 the two groups plot closer together than to any other. The Adelbert frogs have longer legs, minimum of 0.38 as opposed to a maximum TL/SV 0.36. The call of the Eipomek species is remarkable in its length, most than 100 notes in a series, seven times longer than any call recorded in the Adelberts.

In that it may occur in open country rather than in forest, this species resembles *X. fuscigula*. Within the Eipomek area, the only known sympatric species are *giganteus* and *multisica* which are very much larger (Table II). *Xenobatrachus ocellatus* occurs some 150 km to the east and, as the limits of distribution of the two species are unknown, they may be sympatric somewhere in their ranges. However, *schiefenhoeveli* does not have the characteristic colour pattern of *ocellatus*.

Xenobatrachus tumulus new species

Holotype. – UP 7238, adult male, collected by J.I. MENZIES and Helen FORTUNE HOPKINS in February, 1987 at Mambimap, 1500 m, in the Adelbert Range, Madang Province of Papua New Guinea.

Paratypes. – UP 7236-7, adult males, collected at the type locality.

Etymology. – From the latin "tumulus", a mound or hillock, referring to the short, blunt palatine odontoids.

Vernacular name. – "*Palalangowa*", but this was also applied to the superficially similar *Barygenys parvula*.

Diagnosis. – This species is distinguished from others in the *rostratus* group by a combination of longer legs (TL/SV minimum 0.38), narrowly placed nostrils (minimum EN/IN 1.11), small size (maximum SV 28 mm) and small, rounded, palatine odontoids.

Description of the holotype. – Dimensions : SV 26.91 ; TL 10.28 ; HW 9.87 ; EN 1.81 ; IN 1.42 ; EY 1.66 ; TY 1.86.

Body obese, flattened; head small and scarcely distinct from the body; snout rounded and projecting; canthus rounded, lores oblique; nostrils close to the tip of the snout and close to each other (EN/IN 1.28); eyes small (EY/SV 0.062); tympanic membrane distinct, without any superior fold of skin.

Arms short, fingers moderate, with small disks, 3>4>2>1; legs short (TL/SV 0.38), toes moderate with small disks, 4>3>5>2>1 (fig. 8e).

Dorsal surface mottled brown with a faint mid-dorsal stripe; large partial inguinal ocelli; ventral surface white (pinkish in life), mottled evenly all over with brown; posterior sides of the thighs and cloacal triangle very dark.

Variation. – Critical dimensions and ratios are displayed in Table II and graphed in fig. 7.

The three specimens forming the type series vary only in the degree of mottling and intensity of colour on the ventral side, which in one specimen was brick-red.

Distribution. – Known only from the type locality.

Ecological note. – The three specimens forming the type series were found below ground, after their calls had been recorded, beneath tall grass in abandoned garden sites but others were heard calling in similar places, also in forest. They call both by day and night. The call (fig. 3a) is a series of 9-17 notes.

Comparison with other species. – Within the *rostratus* group this species appears to be most closely related to the Eipomek population and in the discriminant analysis plot (fig. 6) came closer to that one than to any other. However the legs are longer, minimum TL/SV 0.38 compared to a maximum of 0.36. The call shows some similarity but differs in length, consisting of less than 20 notes, rather than more than 100. The Adelbert Ranges are isolated from all other mountain ranges in New Guinea, the closest ranges being the Finisterres, separated by the mouth of the Gogol River, and the Schraders, separated by the lowlands of the Ramu valley. The only contiguous population is the lower altitude *rostratus*, which differs in overall size and relative eye size. There exists virtually no overlap in proportions (fig. 7).

Fig. 9. – (a) *Xenobatrachus schiefenhoeveli* ; (b) *Xenobatrachus ocellatus* ; (c) *Xenobatrachus arfakianus* ; (d) same, brooding young.

Fig. 10. – (a) *Xenobatrachus multisica* , (b) *Xenobatrachus ophiodon* ; (c) *Xenorhina eiponis* , (d) *Xenorhina minima*.

Xenobatrachus ocellatus Van Kampen, 1913

Xenorhina ocellata Van Kampen 1913 : 461. – Type locality : "Hellwig Mountains (±2500 m)", Irian Jaya.

Material examined. – UP 7656-7665, collected by P.A. WOOLLEY 10 km east of Lake Habbema, Irian Jaya, Jayawijaya Division, altitude 2800 m, in October 1988.

Discussion. – ZWEIFEL (1972) distinguished this species from all others with single vomero-palatine spikes by its uniformly dark ventral colouration. In the present series, some individuals have the ventral surface light brown or whitish with brown spotting. Using ZWEIFEL's key, these light-bellied individuals would be identified as *Xenobatrachus rostratus*. In that this is a small, short-legged, single-spiked species, we regard it as a member of the *rostratus* group and so include it here.

Description. – ZWEIFEL (1972) gives a detailed description based on the eight specimens available to him, including the syntypes. There are small differences in dimensions and ratios between those and the present series (fig. 7) which are unlikely to be significant but the colouration requires further comment. Dorsally, these ten frogs vary (in spirit) from blackish-brown to light brown with mottling in the lighter morphs. A mid-dorsal stripe is present in 2 only. Ventral colouration varies from even blackish-brown without discernable markings (4 frogs) through mottled mid-brown (5 frogs) to whitish mottled with light brown (1 frog). A mid-ventral line is present in 5. In spirit the groin markings are vague, forming a distinct ocellus in only 2.

In life these frogs varied from tan through reddish brown to almost black, with vague mottling. The axils, groins and concealed parts of the thighs were brilliant black and yellow (fig. 9b).

Distribution. – The present series does not extend the known distribution of the species which remains restricted to the high mountain region around Lake Habbema, Irian Jaya, all over 2000 m.

Comparison with other species. – *Xenobatrachus macrops* is the only known sympatric species: it has longer legs and larger eyes. Within the *rostratus* group *ocellatus* comes geographically closest to *schiefenhoeveli*, distinguished by much more narrowly placed nostrils. None of the eight specimens of *schiefenhoeveli* in the type series had an entirely dark venter and the brilliant black and yellow groin markings were absent.

Xenobatrachus arfakianus new species

Holotype. – UP 8203, adult male, collected by I. CRAVEN on the track between Makwam and Minyambou, northern Arfak Mountains, Irian Jaya, about 1500 m, in August 1988.

Paratypes. – UP 8204, adult male brooding 20 newly hatched young; UP 8205, subadult male; UP 8206-8, half grown, all collected in the same general area as the holotype.

Vernacular name. – "*Neruwaba*" (Hatam).

Etymology. – Named for the Arfak Mountains, the type locality.

Diagnosis. – A combination of medium size (40-50 mm), moderately long legs (TL/SV mean 0.40), small eyes (EY/SV mean 0.07), single vomero-palatine spikes and a dark-mottled belly is diagnostic.

Description of the holotype. – Body obese, head small and not distinct from the body; snout projecting, rounded in profile and truncate from above; nostrils much closer to the tip of the snout than to the eyes; eye-nostril distance and internarial distance about equal (EN/IN 0.95); eye small (EY/SV 0.071); tympanum smaller than the eye, distinct; one long spike on each vomero-palatine.

Fingers moderately long; terminal disks absent but tips slightly dilated, 3>4>2>1; legs moderately long (TL/SV 0.40); toes long with moderate development of terminal disks, 4>3>5>2>1; no subarticular tubercles but shallow inner metatarsal tubercles present.

Skin quite smooth; dorsum (in spirit) dark slate colour with numerous scattered white spots on the flanks; lips mottled with white; a white diagonal stripe from the eye to below the tympanum; flanks change abruptly to the mottled dark and light of the entire ventral surface (body and limbs); neither groins nor concealed parts of the thighs distinctively coloured.

Variation. – Critical dimensions are given in Table II.

The whole series, juveniles and adults, is remarkably uniform in colour, without noticeable differences.

Colour in life (fig. 9c): back and sides evenly and faintly mottled brown all over, changing abruptly on the flanks to the mottled brown and dull yellow of the ventral surface; iris brown, marbled with gold. One specimen (the holotype) darker and with white-tipped warts on the flanks.

Distribution. – Only known from the type locality.

Ecological note. – The entire type series was collected, around midday, by searching in the leaf litter and below fallen logs and other rubbish on the forest floor. As all six specimens were collected in the course of one hour, the species appears to be fairly common. Finding one adult male brooding approximately 20 newly hatched young (fig. 9d) is confirmation of direct development and male brooding in the genus though most species are known to produce the large-yolked eggs typical of direct-developing New Guinea microhylids.

Xenobatrachus arfakianus is a species with moderately long legs (fig. 11). Its eyes are small and it appears not to be one of the burrowing species as all the specimens were collected in fairly superficial situations. It is sympatric with *Xenobatrachus ophiodon*, collected at the same time, which is smaller, has longer legs and larger eyes and is also probably terrestrial rather than fossorial but no other species of *Xenobatrachus* are known from the "Bird's Head" of west New Guinea.

The call is said to be a single mournful note, uttered by day or night. Such a call was heard, spasmodically, in the area where the frogs were collected but we were unable to associate it with any particular specimens. Stomach contents are referred to in the chapter on "diet".

Comparison with other species. – The only other species of *Xenobatrachus* with dark, mottled, bellies are *ocellatus* and *macrops*. *X. ocellatus* is much smaller (not over 38 mm) and has short legs (TL/SV maximum 0.37). *X. scheepstrai* is in the same size range (40-50 mm) but has much longer legs, a plain belly and a distinctive dorsal colour pattern. *Xenobatrachus multisica* and *Xenorhina parkerorum* are also in the same size range, the former has one, two or three vomerine spikes and a plain belly, the latter has no spikes at all.

This leaves *Xenobatrachus macrops* which is similar in all respects, except eye size, to the new species. In the three adult types, eye size (EY/SV) ranges from 0.069 to 0.072 and in the three half grown, from 0.089 to 0.10, which is expected. ZWEIFEL (1972) gives the eye

size range for *macrops* as 0.073 to 0.111 with a mean of 0.085. This is outside the range of the *arfakianus* adults. The legs of *macrops* are longer on average (TL/SV mean 0.44 compared to 0.40) but the ranges overlap. *Xenobatrachus macrops* is known from moderate to high elevations in the mountains of Irian Jaya but not from the Arfaks. In view of the difference in eye size we feel justified in considering *arfakianus* to be a distinct species though we admit that it is closer to *macrops* than to any other. Currently nine *macrops* and six *arfakianus* are known, when more specimens become available the differences between them may become more (or less) apparent.

Xenobatrachus multisica new species

Holotype. – UP 7405, collected by J.P. BLUM at Munggona, Eipomek Valley, Irian Jaya, Jayawijaya Division, altitude 1800 m, between April and June 1976.

Paratypes. – AMNH 128239-43, MZB 2800a,b,c,d,e, SAM 31822-23, UP 5345-7, UP 5679 (skeleton), UP 5680 (cleared and stained preparation), UP 7401-4, UP 7464, UP 7466, ZSM 105/87, collected as above.

Vernacular names. – "*Nekna*" and "*tutum*" (Eipo). Both names were applied to this species but "*nekna*" was also applied to *Xenobatrachus giganteus*.

Etymology. – Compounded from the latin words "multi", many and "sica", a dagger, referring to the number of palatine odontoids.

Diagnosis. – A combination of medium-large size; 2 (occasionally 3 or 1) vomero-palatine spikes and moderately long legs (TL/SV 0.35-0.46) is diagnostic.

Description of the holotype. – Dimensions : SV 54.92 ; TL 21.35 ; HW 19.45 ; EN 3.20; IN 3.08 ; EY 3.16 ; TY 2.58.

Body obese; head small and scarcely distinct from the body; snout projecting, rounded in profile and slightly truncate from above; nostrils closer to the snout than to the eyes and more or less equidistant from the eyes and from each other (EN/IN 1.04); eyes small (EY/SV 0.06); tympanic membrane not very distinct; two low spikes on each vomero-palatine.

Fingers short, terminal disks present and slightly wider than penultimate phalanges, 3>2>4>1; legs moderately long (TL/SV 0.39); toes fairly long with moderate development of terminal disks, 4>3>5>2>1; virtually no development of subarticular or metatarsal tubercles.

Skin rather smooth but with an "orange peel" texture; dorsum tan with brown stippling and vague longitudinal rows of dark spots on the flanks; a fold of skin over the tympanum and a low dorsolateral fold from eye to groin; ventrum more or less the same tan colour vaguely mottled below the throat and limbs; a dark line from the posterior corner of the eye, over the tympanum and ending at the arm insertion; hind sides of the thighs marbled; palms of hands and soles of feet slate colour.

Variation. – Critical dimensions and ratios are given in Table II.

There is considerable variation in colour among the 24 paratypes but the following features are constant: a dark supratympanic band, slightly raised dorso-lateral folds and vague lines of spots on the flanks. Dorsal colour varies from pale tan to dark brown with irregular stippling and spotting. One dark brown specimen has pale spots all over the

dorsum. Ventral colour varies from tan to rather uniform dark brown with a varying amount of stippling, marbling or spotting. Some specimens have a narrow mid-dorsal dark line.

Colour in life (fig. 10a): very variable but mostly speckled blackish brown, sometimes golden or reddish brown.

The number of spikes on the vomero-palatine is also variable. The majority of specimens have two low spikes on each side, four specimens have three spikes on one or both sides and eight specimens have one spike on either one or both sides. No such variation has been seen in any other *Xenobatrachus* species but, as has already been noted, the known number of specimens representing the two-spiked species is exceedingly small.

Distribution. – Only known from the Eipomek and adjacent Famek Valleys (fig. 1) of west New Guinea.

Ecological note. – Very common, as indicated by their calling, in the grassland and garden areas but difficult to find as they live in the ground usually between 20 and 30 cm deep. Local people say that they also call from banana stems but this is unlikely and unsubstantiated. The call of the male is a single note uttered at intervals, sounding like 'waak'. They call during the day, from below ground, especially in sunny periods.

One male of this species contained frog eggs in its stomach which could be those of the same species. Brooding male microhylid frogs are known to consume their own eggs if disturbed but it is not known if this is the explanation for the present observation.

Comparison with other species. – Three other species of *Xenobatrachus* (*giganteus*, *ophiodon* and *bidens*) have two spikes on each palatine-prevomer, but comparison is hampered by lack of knowledge of variation in these frogs for only three specimens of *giganteus*, four of *bidens* and three of *ophiodon* are known. Maximum leg length (TL/SV) in *giganteus* is 0.36 while the minimum for *multisica* is 0.37. The smallest of three *giganteus* is an adult female 80 mm long while *multisica* is adult at 50 mm. *Xenobatrachus bidens* and *ophiodon* are both small species, adult at less than 30 mm. *Xenobatrachus* species are usually short or very short-legged frogs but *multisica* has longer legs than average. Other long-legged species are *macrops* (which has only one palatine spike and larger eyes) and *obesus* which also has only one spike and a very distinctive colour pattern. Most *Xenobatrachus* are small, less than 40 mm. Apart from *obesus* and *macrops*, the only species with the same size range as *multisica* are *ocellatus*, which has short legs (TL/SV 0.28-0.38) and only one spike and *arfakianus* which has a mottled belly and only one spike. If the presence of vomerine odontoids is disregarded this species would be identified as *Xenorhina parkerorum*, a species which it resembles to an extraordinary degree (compare fig. 10a here and fig. 78 of ZWEIFEL, 1972). ZWEIFEL says, of *parkerorum*, "The vomers bear tiny odontoids but lack enlarged spikes...". The significance of these spikes in distinguishing between *Xenobatrachus* and *Xenorhina* is discussed later.

Xenobatrachus scheepstrai new species

Holotype. – UP 7397, adult female collected by G. SCHEEPSTRA at Angguruk, Irian Jaya, Jayawijaya Division, altitude 1400 m, in June 1979.

Paratype. – ZSM 103/87, adult female, collected with the holotype.

Vernacular name. – "*Sambono*".

Etymology. – Named for Dr. Gert SCHEEPSTRA, medical officer at Angguruk.

Diagnosis. – A combination of a single palatine spike, small eyes, very long legs (TL/SV 0.47-0.51) and unique colour pattern is diagnostic.

Description of the holotype. – Dimensions : SV 48.42 ; TL 25.10 ; HW 16.60 ; EN 3.13 ; IN 2.83 ; EY 3.07 ; TY 2.87.

Body obese; head small and not very distinct from the body; snout projecting, probably rounded in profile but slightly damaged; canthus rounded, lores oblique, concave; nostrils nearer to the tip of the snout than to the eye and placed fairly close together (EN/IN 1.11); eyes small (EY/SV 0.06); tympanic membrane fairly distinct, surmounted by a shallow skin fold; 1 small spike on each palatine-prevomer.

Fingers moderate in length, 4>3–2>1; slightly expanded at the tips; subarticular tubercles absent; legs long (TL/SV 0.51); toes long, 4>3>5>2>1; disks moderately developed; tubercles absent.

Skin smooth, shiny, plain dark brown above, with a narrow light mid-dorsal line which bifurcates and runs down the posterior sides of the hind limbs; dorsal colour sharply distinct from the ventral; entire ventral surface, including the limbs and the inner two fingers and three toes, white; throat partly mottled, elsewhere plain.

Variation. – The holotype and paratype are virtually identical in appearance and differ little in dimensions or proportions (Table II). We have no information on the colour in life.

Ecological note. – No information is available.

Distribution. – Known only from the type locality.

Comparison with other species. – Using the key of ZWEIFEL (1972) this species would be identified as either *obesus* (if size is disregarded), *macrops* or *mehelyi*. *Xenobatrachus macrops* has larger eyes (EY/SV 0.073-0.111); *mehelyi* has shorter legs (TL/SV 0.37-0.34). The new species resembles *obesus* in leg length and the colouration is similar in that dorsal and ventral colours are sharply demarcated and a mid-dorsal line is present but the actual colours are different. However, *obesus* is large; adult females measure 65-75 mm, while the holotype and paratype of *scheepstrai* are adult at 48 and 51 mm so it seems very unlikely that the two are conspecific though they may be sibling species.

Xenobatrachus bidens (Van Kampen, 1909)

Xenorhina bidens Van Kampen, 1909: 39. – Type locality: Digoel River, Irian Jaya.

Discussion. – One specimen, UP 7464, collected in rain forest on the upper Turama River, Gulf Province of Papua New Guinea (fig. 1), extends the distribution of this species somewhat further to the east. This appears to be a lowland species (all localities are near sea level) occurring south of the central mountain chain from the neck of the "Bird's Head" to the Gulf of Papua. Only four specimens are known and either the species is rare or, more probably, secretive. No additional information on ecology is available.

Xenobatrachus giganteus Van Kampen, 1915

Xenobatrachus giganteus Van Kampen, 1915: 40. – Type locality: Bijenkorfbivak, upper Lorentz River, 1700 m, Irian Jaya.

Material examined. – UP 7400, adult female, collected by J.P. BLUM in rain forest above the Eipomek Valley at 2400 m in June, 1979.

Vernacular name. – "*Nekna*" (Eipo).

Discussion. – This is only the third specimen of this species to be known, the other two being the lectotype and paralectotype and the new specimen requires little modification of the diagnosis given by ZWEIFEL (1972). Ratios (Table II) fall slightly outside those given by ZWEIFEL but the Eipomek specimen has been fixed in a position with the head flexed making accurate measurement difficult. Thus no significance should be attached to these differences.

Description. – Dorsal colour tan with dark bluish-grey stippling, more dense on the head; a fine dark mid-dorsal line divides and continues down the back of the thighs; ventral side tan with extensive mottling.

Ecological note – Local people say that this species may be found in forest and higher altitude grassland but is very rare. Our specimen was found in a small hollow below moss and fern by the edge of a stream in forest. We have no information about the call.

Distribution. – Eipomek is approximately 140 km east of the type locality near the upper Lorentz River and the new site is 700 m higher in altitude.

Xenobatrachus ophiodon Peters & Doria, 1878

Xenobatrachus ophiodon Peters & Doria, 1878: 432. – Type locality: "Hatam, Arfak Mountains". There were originally two syntypes but now only one exists (CAPOCACCIA, 1957: 219).

Material examined. – Two specimens, UP 8209-10, collected in forest on the track between Makwam and Minyambou, northern Arfak Mountains at an altitude of 1500 m in August, 1988.

Discussion. – This species has not been found since BECCARI's original collection was made in 1875. "Hatam" is not a place but the name of the people inhibiting the northern Arfaks and BECCARI's type locality is probably not far from the Makwam-Minyambou track. These two specimens were found about noon when searching below leaf litter and fallen logs on the forest floor. Both are adult females (SV 24.8 and 28.1 mm) with eggs. In the larger of the two the eggs appear to be fully developed.

Xenobatrachus ophiodon is one of the longer legged, larger eyed species with well developed toe disks and these characters suggest that it is more terrestrial than fossorial. This is supported by the fact that they were not found in the soil, as the fossorial species usually are, but merely concealed below superficial deposits.

The description of the lectotype by ZWEIFEL (1972) fits these two specimens in all material ways but the toe disks are, for a *Xenobatrachus*, quite well developed. Fig. 10b shows one of the specimens in life. Dorsal colour red-brown or yellow-brown in a distinct broad band; flanks paler with much dark mottling; lores and sides of the head darker; ventral surface yellowish, reticulated on throat and hind limbs; iris dark with gold marbling; tympanum set in a pale patch.

The colour in spirit is not much different except that the yellow belly colour has disappeared.

Xenobatrachus species

Discussion. – A single specimen, UP 8120, from Kowat, 1000 m in the Adelbert Mountains was identified in the discriminant analysis programme as *Xenobatrachus subcroceus*. It is a small frog (SV 30.84) with long legs (TL/SV 0.44) and a narrow snout (EN/IN 1.25) and is, indeed, indistinguishable morphologically from *subcroceus*. However the call is quite different, with long notes (0.25–0.3 s) at rather long intervals (1.0–1.5 s). The call of *subcroceus* (fig. 2a) consists of short notes at short intervals. *Xenobatrachus mehelyi* is another small, long-legged species. The note repetition rate of that species is about the same as in the Adelbert frog but individual notes (fig. 2b) are shorter. Currently, *Xenobatrachus subcroceus* is known only from the type locality near Lae, 290 km distant. It looks as if this Adelbert frog represents yet another undescribed species but we are reluctant to describe it until more material is available and we have some idea of the variation in call structure of *subcroceus*. Richard ZWEIFEL has kindly supplied a sonogram of an identical call, but without voucher specimen, recorded near Wanuma, also in the Adelbert Mountains.

Xenorhina eiponis new species

Holotype. – UP 7407, adult female, collected by J.P. BLUM at the Base Camp, Eipomek Valley, Irian Jaya, Jayawijaya Division, altitude 1800 m, in June, 1979.

Paratypes. – AMNH 12834, MZB 2803, UP 7406, UP 7503-5, ZSM 106/87, all collected by BLUM at Munggona, altitude 1800 m.

Etymology. – Named after the Eipo People, land owners of the type locality.

Vernacular name. – "*Kwasa*" (Eipo).

Diagnosis. – Distinguished from all other species of *Xenorhina* by a combination of long legs (TL/SV 0.48-0.52), enlarged disks on fingers and toes and distinctive colour pattern.

Description of the holotype. – Dimensions : SV 34.68 ; TL 16.82 ; HW 9.88 ; EN 2.72 ; IN 2.35 ; EY 2.79 ; TY 2.63.

Body moderately obese; head small, pointed and merging into the body with scarcely any constriction at the neck; snout rounded in profile, rather truncate from above; canthus rounded, lores flattish, slightly oblique; eyes small (EY/SV 0.08); nostrils much nearer to the tip of the snout than to the eyes and closer to one another than to the eyes (EN/IN 1.16); tympanic membrane moderately distinct, with a shallow fold of skin above; skin smooth.

Fingers long, 3>2=4>1 with distinct disks about twice the width of the penultimate phalanx, without subarticular tubercles; legs long (TL/SV 0.49); toes long, 4>3>5>2>1, with distinct disks about twice the width of the penultimate phalanges, very shallow subarticular and metatarsal tubercles.

Colour (in spirit): medium brown above, more or less plain, with a thin mid-dorsal line; flanks paler with numerous shallow, white-tipped warts; concealed parts of the thighs and groins not different; white stripe from upper lip to arm insertion. Ventral surface white (bright yellow in life), spotted dark brown on the throat.

Variation. – Critical dimensions and proportions are shown in Table II. The colouration is uniform, two specimens have vague ocelli in the groins and the amount of dark blotching

on the throat is variable. Otherwise there is little difference between the six specimens. The colour in life is shown in fig. 10c.

Ecological note. – This species is also found in secondary vegetation but usually only in the wetter places. Specimens collected by BLUM were found amongst moss, short grass, etc., but not deep in the soil as with the *Xenobatrachus* species previously described. The longer legs and larger eyes suggest a terrestrial rather than fossorial habitat but we have no positive information on this.

Distribution. – Known only from the Eipomek Valley.

Comparison with other species. – The only other species of *Xenorhina* with legs approaching this length is *oxycephala* (TL/SV 0.40-0.45), widely distributed in lowland localities of western and central New Guinea. This species has smaller finger disks and nostrils more closely placed (EN/IN minimum 1.30 compared to 1.19 maximum in *eiponis*). Using ZWEIFEL's 1972 key, this new species would be identified as *parkerorum* which is much larger (up to 68 mm in length), has shorter legs (maximum TL/SV 0.46) and a uniformly dark ventral surface.

Xenorhina eiponis could be confused with the longer legged *Xenobatrachus* species, *bidens, macrops, mehelyi, obesus* and the new species *scheepstrai* but only *obesus* has legs as long and that species is double the size and has a very distinct colour pattern, a light brown dorsum and a broad complete or interrupted black lateral band. In the case of ambiguity it would be necessary to examine the palate for presence or absence of vomero-palatine spikes.

Xenorhina species

Discussion. – Two specimens, UP 5737 and 7476, adult female and male, collected by J.P. BLUM at Munggona in May, 1975, cannot be allied with any previously or herein described species.

These specimens display a combination of small size (21-22 mm), short legs (TL/SV 0.32), very closely placed nostrils (EN/IN 1.32 and 1.48), and disks on toes but not on fingers.

The only other small species (adult at less than 30 mm) are *bouwensi* and *minima*. These specimens differ from *minima* in that the EN/IN ratio is higher and toe disks are present. The colour is also different. *Xenorhina bouwensi* does have toe disks but its legs are longer, minimum TL/SV 0.37. *Xenorhina bouwensi* is known from only two widely separated localities, in the western half of New Guinea, between 1000 and 1250 m. The Arfak Mountains and the Star Mountains are 800 km distant and *bouwensi* could be expected to occur in intermediate localities at comparable altitude. Since the sample of *bouwensi* that ZWEIFEL reported is of reasonable size (17 specimens), it is probable that the differences in TL/SV ratio are genuine.

Without more specimens or additional data, we cannot put a name to these frogs.

A further two specimens, PM 2340d-e, cannot be identified. These have no locality or collector data but were numbered with the two *Xenobatrachus anorbis* paratypes (PM 23540a-c) and were surely collected somewhere in western Papua New Guinea.

They are small frogs (SV 27 and 33 mm) with moderately short legs (TL/SV 0.32, 0.38) and small eyes (EY/SV 0.06, 0.08). They have distinct disks on toes but not on fingers. They come closest to *bouwensi* but are larger, that species does not exceed 25 mm. Other species in this size range are *minima* and *similis* which have no disks at all, and *eiponis* and *oxycephala*

which have much longer legs (TL/SV 0.48-0.52).

Without adequate data we cannot put a name to these specimens either.

Xenorhina minima (Parker, 1934)

Asterophrys minima Parker, 1934 : 67. – Type locality: Went Mountain, upper Lorentz River, 1000-1360 m, Irian Jaya.

Material examined. – UP 7467, Angguruk, 1400 m, collected by G. SCHEEPSTRA; UP 7472, Serabum, 2400 m; AMNH 128235-6, MZB 2802a,b, UP 5677, ZSM 107/87, collected on the route between Serabum and the pass to the Heime valley at 3500 m by J.P. BLUM.

Since only two specimens of this species were previously known, a full diagnosis and description are given here.

Vernacular name. – "*Moknera*" (Eipo).

Diagnosis. – A small species (maximum SV 35 mm) with short legs (mean TL/SV 0.32), widely placed nostrils (mean EN/IN 0.84) and without disks on fingers or toes.

The only other small species of *Xenorhina* (less than 35 mm long) is *bouwensi* which does have disks on the toes and has nostrils closer together.

Description. – Critical body dimensions and ratios are given in Table II.

Body obese; head tapering but slightly demarcated by a constriction at the neck; snout rounded in profile, rather truncate from above; canthus rounded, lores concave, oblique; eye small (EY/SV 0.054-0.078); nostrils nearer to the snout than to the eyes; tympanic membrane clearly visible and with a small fold of skin above.

Fingers moderately long, 3>4>2>1, without disks or subarticular tubercles; toes moderately long, 4>3>5>2>1, without disks though there are traces of circum-marginal grooves at the apices. Subarticular and inner metatarsal tubercles present.

Skin smooth; dorsum tan to dark grey-brown with irregular mottling in the lighter morphs; occasional white or yellow spots on the flanks of two specimens; light mid-dorsal and inguinal lines in three; concealed parts of the thighs not different in colour; dorsal colour merges into the ventral cream without abrupt transition; ventral all over cream with a varying amount of dark stippling, denser in darker morphs; a dark stripe from the eye over tympanic membrane to the shoulder; upper lip whitish; hands and feet pale. Colour in life is shown in fig. 10d.

Ecological note. – Specimens collected by BLUM were found in wet places below fern or moss clumps, especially where water was running. The call, a single note repeated at intervals during the day, is said to herald the onset of rain, hence the vernacular name "rain-bringing frog".

Distribution. – The type locality on the upper Lorentz River is approximately 140 km west of Eipomek but extends the altitudinal range from approximately 1000 to 3500 m.

Discussion. – The nine frogs representing this species form a uniform series despite being collected over an altitudinal range of 2100 m; there is nothing to distinguish those from high altitudes from the others.

DISCUSSION

The present paper adds a further nine species to the previously known 15 in the two genera *Xenobatrachus* and *Xenorhina*, three of which come from one fairly discrete area (the Eipo Valley) of west New Guinea. This may seem a surprisingly large number of closely related species and extrapolation indicates that there may be many more yet to be discovered in the western half of the island. However, consideration of the form and habits of these frogs suggests that their lack of mobility, low fecundity and the nature of the terrain may lead to a high degree of endemism with many species very restricted in distribution. Knowledge of these two genera has lagged behind that of a superficially similar but more easterly occurring genus, *Barygenys*, where four new species have been discovered in recent times and each one known only from a single circumscribed area.

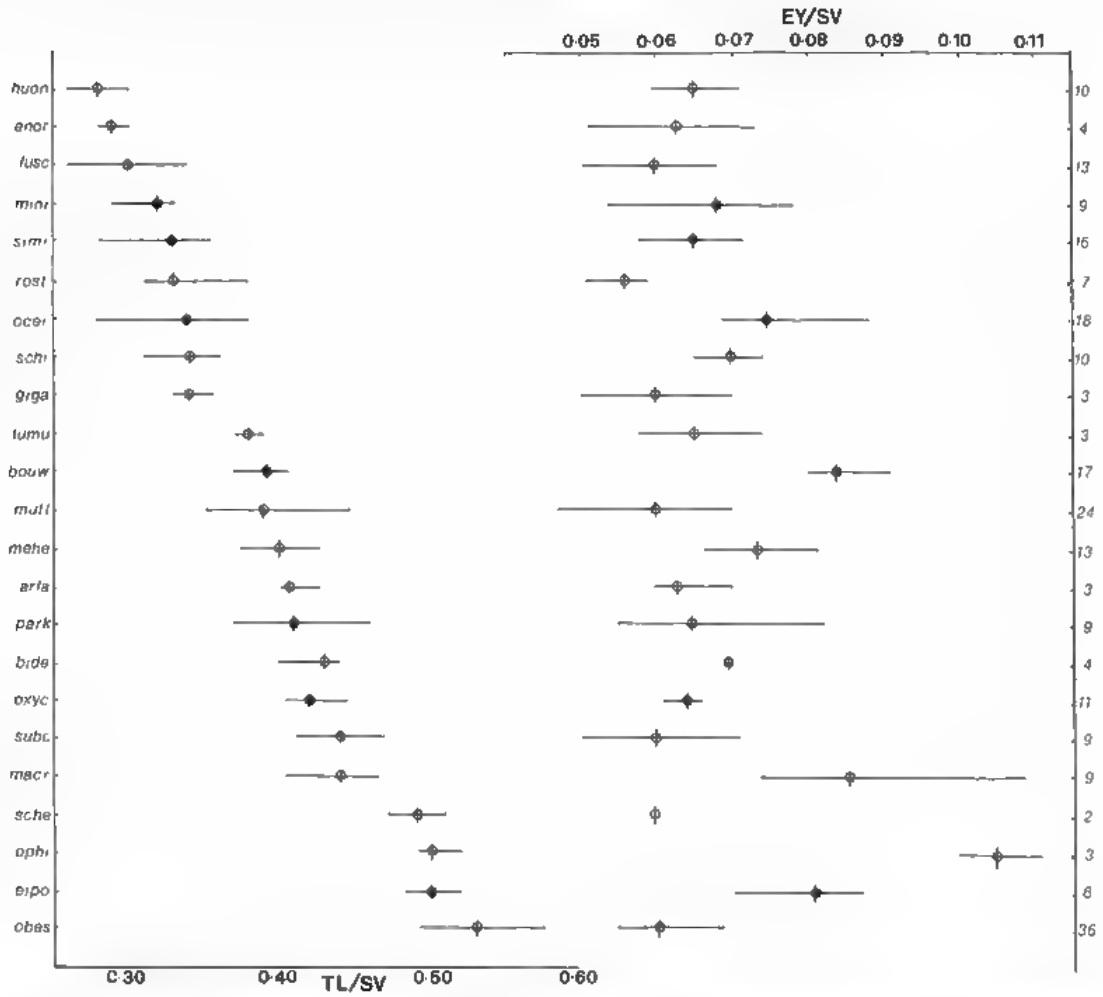

Fig. 11. – Comparative leg length (TL/SV), in ascending order, and eye size (EY/SV) in *Xenobatrachus* and *Xenorhina* species. Horizontal bars represent the range, vertical bars are the mean for each ratio. Open circles denote *Xenobatrachus* species, solid circles are *Xenorhina*. Numbers in the right hand column are sample sizes. Data partly from ZWEIFEL (1972).

Xenobatrachus and *Xenorhina* are closely related genera differing only in the possession by the former of one or more tooth-like processes on the palatine-prevomer and BURTON (1986) has discussed the value of this character, pointing out the possible combination of the two genera under the senior name, *Xenorhina*. Both genera include species exhibiting synapomorphies associated with a fossorial existence, including, among other things, short hind limbs and small eyes but there is considerable variation in both genera suggesting that a certain amount of parallel evolution has occurred. Unfortunately so little (or nothing) is known about the ecology of many species that it is almost impossible to say if those with longer legs are more terrestrial, and less fossorial, than those with very short legs. Comparative leg length (in ascending order) and eye size, in all species of both genera are shown in fig. 11. *Xenobatrachus* includes the species with the shortest legs (*huon, fuscigula* and *anorbis*) and that with the longest (*obesus*) but *Xenorhina* species display almost as much variation. Correlation of eye size with leg length is difficult as larger frogs tend to have relatively smaller eyes and there is no reliable way of making a correction for this factor. Also it is difficult to obtain accurate, repeatable, measurements of minute eyes in specimens which may not have been well preserved in the first place. This probably accounts for the greater variation in eye size than in leg length in individual species. Nevertheless, some species stand out for comment.

Eight species of *Xenobatrachus* are known from the authors' experience to be fossorial. Four of these (*fuscigula, rostratus, schiefenhoeveli* and *anorbis*) have very short legs and very small eyes while four others have legs in the middle range though the one with the longest legs in this group, *subcroceus*, has smaller than average eyes. Among the longer-legged species, *Xenobatrachus macrops*, *X. ophiodon* and *Xenorhina eiponis* have larger than average eyes. Nothing has been recorded of the habits of *macrops* but BLUM's experience of *X. eiponis* indicates that it is not a burrowing species. We have earlier mentioned that *arfakianus* and *ophiodon* do not appear to be burrowing species either. Despite our lack of knowledge of many species, it seems likely that both genera contain fossorial and terrestrial types.

Variation in vomero-palatine spike number in *Xenobatrachus multisica* suggests that there may be a species yet to be discovered in which spikes are either absent or present thus blurring the distinction between the two genera even further. There is much available evidence, discussed by BURTON (1986), which supports monophyly in *Xenorhina* sensu lato (i.e. the characters of the tribe Xenorhinini), but variation in vomero-palatine spike number does shed increasing doubt on the monophyly of *Xenobatrachus*.

IDENTIFICATION OF *XENOBATRACHUS* AND *XENORHINA* SPECIES

Determination of which genus to allocate a specimen is usually hampered by the difficulty of inspecting the palate unless, an unlikely event, the specimen has been fixed with the mouth open. The only recourse is to cut away the floor of the mouth with consequent destruction of musculature. For this reason, identification without destructive investigation is desirable and we offer a combined key to the two genera after means of distinguishing them from other microhylid frogs.

Species of these two genera are not easily confused with other microhylid frogs in New Guinea on account of their rotund bodies, small pointed heads, minute eyes and, frequently, short legs. The genus most closely resembling these two is *Barygenys*, which also includes

squat, short-legged burrowing frogs. However, *Barygenys* species always have three or five vertical ridges on the tip of the snout, absent in *Xenobatrachus* and *Xenorhina*. Moreover, *Barygenys* species are confined to the eastern half of New Guinea, none are known from Irian Jaya and cases of sympatry are rare. Some species of *Callulops* are obese and have short legs but the head is always broader (EN/IN <1.00 except in a few examples of three species) and the eyes are larger (mean EY/SV always >0.10).

Knowing the place of origin of the specimen is necessary for positive identification in many cases. Note also that the possibility of range extension and occurrence of undescribed species is high. The following key mainly uses external characters and should suffice in the majority of cases but confirmation of identity may have to be sought by anatomical investigation and the reader is referred to the monograph of ZWEIFEL (1972) for anatomical detail.

KEY TO SPECIES OF *XENOBATRACHUS (Xb.)* AND *XENOHINA (Xr.)*

1. Size large (SV >60 mm) AND legs long (TL/SV >0.49); distinctive colouration including a mid-dorsal stripe and a dark lateral band — *Xb. obesus*
   Not this combination — 2
2. Size large (SV>75) AND legs short (TL/SV <0.38) — *Xb. giganteus*
   Not this combination — 3
3. Size medium (SV 40-70) AND legs fairly long (TL/SV 0.35-0.46) — 4
   Not this combination — 10
4. Eyes larger (EY/SV 0.073-0.111) — 5
   Eyes smaller (EY/SV <0.073) — 6
5. West New Guinea only (west of 139°); vomero-palatine spikes present — *Xb. macrops*
   East New Guinea only (east of 140°); vomero-palatine spikes absent — *Xr. parkerorum*
6. Finger disks absent (finger tips no broader than the penultimate phalanges) — 7
   Finger disks present (finger tips distinctly swollen) — 9
7. Legs shorter, TL/SV<0.40 — 8
   Legs longer, TL/SV>0.39 — *Xb. arfakianus*
8. Lowland, not over 1500 m; vomero-palatine spikes present — *Xb. rostratus*
   Montane, only above 2000 m; vomero-palatine spikes absent — *Xr. simulis*
9. EN/IN ratio more than 1.30 — *Xr. oxycephala*
   EN/IN ratio less than 1.31 — 10
10. Vomero-palatine spikes absent — *Xr. parkerorum*
    Vomero-palatine spikes present — *Xb. multisica*
11. Eyes larger (EY/SV 0.10-0.11); size small (SV 30 mm); Arfak Mountains only — *Xb. ophiodon*
    Eyes smaller (EY/SV <0.10); various localities — 12
12. Size larger (SV >47); legs very long (TL/SV >0.46) — *Xb. scheepstrai*
    Not this combination — 13
13. Legs longer (TL/SV >0.47) AND eyes larger (EY/SV >0.069) — *Xr. eiponis*
    Not this combination — 14

14. Throat and usually whole ventral surface entirely dark; high altitudes in west New Guinea only *Xb. ocellatus*
Not this combination 15

15. Legs longer (TL/SV >0.41); hillslopes of Rawlinson Mountains *Xb. subcroceus*
Not this combination 16

16. Legs short (TL/SV <0.33); high altitudes (over 1600 m) in Huon Peninsula mountains only *Xb. huon*
Not this combination 17

17. Neither fingers nor toes with disks 18
Toes, at least, with disks wider than the penultimate phalanges 20

18. Vomero-palatine spikes present 19
Vomero-palatine spikes absent *Xr. minima*

19. Size small (SV<25); belly pale, plain *Xb. anorbis*
Size larger (SV>30); belly dark, mottled *Xb. ocellata*

20. Legs short (TL/SV<0.31); throat dark pigmented; central highlands of Papua New Guinea only *Xb. fuscigula*
Not this combination 21

21. Eyes larger (EY/SV >0.079) 22
Eyes smaller (EY/SV <0.080) 23

22. Size smaller (SV <25); eyes smaller (EY/SV <0.082); west New Guinea only; vomero-palatine spikes absent *Xr. bouwensi*
Size larger (SV >25); eyes larger (EY/SV >0.080); east and central New Guinea only; vomero-palatine spikes present *Xb. mehelyi*

23. Legs longer (TL/SV >0.39); lowlands of south New Guinea only; 2 vomero-palatine spikes *Xb. bidens*
Legs shorter (TL/SV <0.40); Adelbert Mountains only; one vomero-palatine spike *Xb. tumulus*

Acknowledgements

Blum's work was part of the programme "Man, Culture and Environment in the Central Highlands of Irian Jaya", organized by Drs. G Koch and K. Helfrich. Blum thanks the Deutsche Forschungsgemeinschaft for financial support and for making his work possible and Dr. Wulf Schiefenhoevel for leadership and guidance during the Eipomek expeditions. Thanks are also due to the Indonesian Institute of Scientific Research and to Cenderawasih University, Jayapura. Menzies' work was supported by the University of Papua New Guinea and by the Papua New Guinea National Museum. Further thanks are due to Dr. Gert Scheepstra, medical officer at Angguruk who collected frogs for us but was also particularly helpful to members of the expedition during the retreat from the disastrous earthquake in 1976, Dr. V. Heeschen who provided accommodation for Blum in Kosarek and Ian Craven who guided Menzies into the Arfak Mountains. Dr. Zweifel of the American Museum of National History in New York made a preliminary examination of some specimens and was kind enough to make his notes available to us. Dr. P.A. Woolley collected a series of *Xenobatrachus* near Lake Habbema and presented them to us.

MENZIES thanks the Papua New Guinea University of Technology for use of its Sonagraph and Dr. H.G. COGGER for supplying a tape record of *Xenobatrachus fuscigula*.

Publication of the colour plates (figs. 9 and 10) was made possible by grants from the University of Papua New Guinea and the Society of Friends of the Papua New Guinea National Museum.

ZUSAMMENFASSUNG

Umfangreiches Sammelmaterial von Froschen der Gattungen *Xenobatrachus* und *Xenorhina* aus Irian Jaya (West-Neuguinea) und Papua Neuguinea erlauben, genauere Aussagen über Verbreitung, Ökologie und Systematik dieser Frösche zu machen. Anhand von morphometrischen Untersuchungen und Untersuchungen der Lautäusserungen konnte die bislang als *Xenobatrachus rostratus* bekannte Artengruppe in sechs Arten unterteilt werden. Neun neue Arten wurden beschrieben. Magen- und Darmuntersuchungen von vierzig Exemplaren dreizehn verschiedener Arten bestätigen die Annahme, dass diese Frösche spezialisierte Regenwurmfresser sind. Vielleicht hängt mit der spezifischen Nahrung auch die besondere Gestaltung der Zunge zusammen. Im Gegesatz zu anderen Microhyliden ist sie teilweise festgewachsen, nicht vorstreckbar jedoch zu einer Röhre verformbar. Tiefe, längsverlaufende Furchen, dicht besetzt mit Drüsenzellen, vergrößern die Zungenoberfläche. Auf die "Zähne" des Rachenraumes, charakteristisch für *Xenobatrachus*, wird hingewiesen.

Die verwandtschaftliche Beziehung der Gattungen *Xenobatrachus* und *Xenorhina* wird diskutiert. Der jetzige Kenntnisstand erlaubt nicht, trotz ähnlicher Morphotypen und ähnlicher Lebensweisen, beide Gattungen zusammenzufassen.

Insgesamt wurden neun neue Arten und zwei Arten neu beschrieben. Ein Bestimmungsschlüssel fur alle bekannten Arten beider Gattungen wurde erstellt.

RÉSUMÉ

La constitution par les auteurs, dans l'est et l'ouest de la Nouvelle Guinée (Irian Jaya, Indonésie, et Papouasie Nouvelle Guinée), d'une importante collection d'espèces des genres *Xenobatrachus* et *Xenorhina*, permet d'offrir quelques commentaires sur l'écologie et la systématique de ces Anoures mal connus. Une combinaison de données portant sur les chants des mâles et sur la morphométrie révèle que les animaux jusqu'ici connus sous le nom de *Xenobatrachus rostratus* appartiennent en fait à un complexe d'au moins six espèces distinctes qui peuvent être ou non étroitement apparentées. Cinq de celles-ci sont ici décrites comme nouvelles, et un néotype est désigné pour *Xenobatrachus rostratus*.

L'examen des contenus stomachaux de 40 spécimens appartenant à 13 espèces suggère que celles-ci ont un régime alimentaire spécialisé, composé principalement de vers de terre, ce qui ferait de ces Anoures l'équivalent écologique des Gymnophiones, absents en Nouvelle Guinée. La fonction éventuelle des "épines" voméro-palatines caractéristiques de *Xenobatrachus* fait l'objet d'une discussion, et la structure particulière de la langue de ces animaux est décrite.

Deux espèces (*Xenobatrachus rostratus* et *Xenorhina minima*) sont redéfinies et neuf espèces nouvelles décrites. Des données sur la répartition et sur l'écologie sont fournies dans

la mesure où elles sont disponibles. Les relations entre *Xenobatrachus* et *Xenorhina* sont discutées. Pour l'instant il n'est pas possible de réunir ces deux genres sous le nom le plus ancien (*Xenorhina*), mais des éléments nouveaux pourront peut-être amener à le faire dans l'avenir. Chacun de ces deux genres comporte une série de formes menant progressivement d'espèces aux pattes courtes et aux yeux réduits, connues pour mener une existence souterraine, à des espèces aux longues pattes et aux yeux bien développés, dont le mode de vie est probablement terricole. Une clé d'identification de toutes les espèces des deux genres est proposée.

(Résumé rédigé par Alain DUBOIS*)*

LITERATURE CITED

ARCHBOLD, R., RAND, A.L. & BRASS, L.J., 1942. – Results of the Archbold Expeditions. No. 41. Summary of the 1938-1939 New Guinea Expedition. *Bull. Amer. Mus. nat. hist.* **79** : 197-288.

BRONGERSMA, L.D., 1954. – Een zoologische verzamelreis in Nieuw-Guinea. *Natuurk. Voordrachten, Nieuwe Reeks*, **32** : 149-162.

BULMER, R.N.H. & TYLER, M.J., 1968. – Karam classification of frogs. *J. Polynesian Soc.*, 77 : 333-385.

BURTON, T.C., 1983. – *The phylogeny of the Papuan subfamily Asterophryinae (Anura: Microhylidae)*. University of Adelaide, Ph.D. thesis : i-xiii + 1-283.

----- 1986. – A reassessment of the Papuan subfamily Asterophryinae (Anura: Microhylidae). *Rec. South Aust. Mus.* **19** : 405-450.

CAPOCCACIA, L., 1957. – Catalogo dei tipi di anfibi del Museo Civico di Storia Naturale di Genova. *Ann. Mus. civ. stor. nat. Genova*, **69** : 208-222.

CRAVEN, I. & DE FRETES, Y., 1978. – *The Arfak Mountains nature conservation area, Irian Jaya*. Bogor, Indonesia, World Wildlife Fund and Ministry of Forestry: i-xv + 1-175.

DIXON, W.J., 1983. – *BMDP Statistical software*. Berkeley, University of California Press.

DUBOIS, A., 1988. – Miscellanea nomenclatorica batrachologica (XVII). *Alytes*, 7 : 1-5.

DWYER, P.D., 1975. – Observations on the breeding biology of some New Guinea murid rodents. *Aust. Wildl. Res.*, **2** : 33-45.

HAHL, A., 1980. – *Governor in New Guinea*. Edited and translated by P.G. SACK & D. CLARK. Canberra, Australian National University Press: i-xii + 1-186.

HOFFMANN, G.I. & HOFFMANN, M., 1985. – *Klimabeobachtungen in Etpomek, Irian Jaya (West-Neuguinea). Beitrag 9a der Schriftenreihe. Mensch, Kultur und Umwelt im zentralen Bergland von West-Neuguinea*. Berlin, Reimer Verlag: 1-224.

MÉHELY, L. v., 1898. – An account of the reptiles and batrachians collected by Mr Lewis Biro in New Guinea. *Termesz. Fuz.*, **21** : 165-178.

MENZIES, J.I., 1975. – *Handbook of common New Guinea frogs*. Wau, Papua New Guinea, Ecology Institute, Wau Ecology Institute Handbook No.1: i-viii + 1-75.

MENZIES, J.I. & TYLER, M.J., 1977. – The systematics and adaptations of some Papuan microhylid frogs which live underground. *J. zool. Lond.*, **183** : 431-464.

PARKER, H.W., 1934. – *A monograph of the frogs of the family Microhylidae*. London, British Museum (Natural History): i-viii + 1-208.

PETERS, W. & DORIA, G., 1878. – Catalogo dei rettili e dei batraci raccolti da O. BECCARI, L.M. D'ALBERTIS e A.A. BRUIJN nella sotto-region e Austro-Malese. *Ann. Mus. Civ. Stor. nat. Genova.*, **13** : 325-450.

TYLER, M.J., 1963. – A taxonomic study of amphibians and reptiles of the Central Highlands of New Guinea, with notes on their ecology and biology. I. Anura: Microhylidae. *Trans. Roy. Soc. S. Aust.*, **86** : 1-29.

VAN DEUSEN, H.M., 1978. – Results of the Archbold Expeditions. No. 101. Summary of the seventh Archbold Expedition. *Amer. Mus. Novitates*, **2660** : 1-21.

VAN KAMPEN, P.N., 1909. – Die Amphibien Fauna von Neu-Guinea, nach der Ausbeute der Niederländischen Süd-Neu-Guinea Expedition von 1904-1905 und 1907. *Nova Guinea*, Leiden, **9** : 31-49.

----- 1913. – Amphibien, gesammelt von den Niederländischen Süd-Neu-Guinea-Expeditionen von 1909-1910. *Nova Guinea*, Leiden, **9** (Zool.): 453-465.

----- 1915. – Amphibien von Neu-Guinea. (Sudwest-Neu-Guinea-Expedition 1912/1913). *Nova Guinea*, Leiden, **13** (Zool): 39-41.

ZWEIFEL, R.G., 1960. – A new microhylid frog from the Adelbert Mountains of New Guinea. *Amer. Mus. Novitates*, **2012** : 1-7.

----- 1972. – Results of the Archbold Expeditions. No. 97. A revision of the frogs of the subfamily Asterophryinae, family Microhylidae. *Bull. Amer. Mus. nat. hist.*, **148** : 411-546.